March 18, 1998 F/NW03

MEMORANDUM FOR: Tony Nigro, State of Oregon
Jim Hoff, State of Washington
Jim Yost, State of Idaho
John Sisk, State of Alaska
Brian Marotz, State of Montana
Raphael Bill, Confederated Tribes of the Umatilla
Patty O'Toole, Confederated Tribes of the Warm Springs Res.
Lynn Hatcher, Yakama Indian Nation
Si Whitman, Nez Perce Tribe
Jerry Marco, Confederated Tribes of the Colville Reservation
Joe DosSantos, Confed. Salish & Kootenai Tribes of the Flathead
Kelly Lillengreen, Coeur d'Alene Tribe of Idaho
Bill Towey, Kalispel Tribe
Sue Ireland, Kootenai Tribe of Idaho
David Arthaud, Shoshone-Bannock Tribes of Fort Hall
Terry Gibson, Shoshone-Paiute Tribes of Duck Valley Res.
Keith Underwood, Spokane Tribe of Indians
Haace St. Martin, Burns Paiute Tribe

FROM: Brian J. Brown

SUBJECT: DRAFT Supplemental Biological Opinion on Operation of the Federal Columbia River Power System Including the Smolt Monitoring Program and the Juvenile Fish Transportation Program, During 1998 and Future Years

The subject draft Supplemental Biological Opinion is attached for your review and comment. ***Comments will be accepted through April 3, 1998.***

The draft includes a revised proposed action, and the conclusion is based on the revised action. The Corps of Engineers, the Bonneville Power Administration, and the Bureau of Reclamation (Action Agencies) have not yet submitted a specific revised action, but they have agreed with the need for changes from what was proposed in the Biological Assessment, and have also agreed that this draft, including the draft revised action, is adequate for the purposes of seeking comment from the State and Tribal sovereigns.

Following receipt of comments, and additional discussion that may occur before the close of comments, the Action Agencies will provide a specific revised action. NMFS will then conclude the consultation. We intend to conclude the consultation by April 10, 1998.

Please address comments to:

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Brian Allee, Columbia Basin Fish and Wildlife Authority
Bob Heinith, Columbia River Inter-Tribal Fish Commission

Endangered Species Act - Section 7
Consultation

DRAFT
SUPPLEMENTAL BIOLOGICAL OPINION

Operation of the Federal Columbia River Power System
Including the Smolt Monitoring Program and the Juvenile Fish Transportation Program,
During 1998 and Future Years

Agencies: U.S. Army Corps of Engineers
Bonneville Power Administration
Bureau of Reclamation
National Marine Fisheries Service

Consultation Conducted By: National Marine Fisheries Service,
Northwest Region

Date Issued: ________________

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I. OBJECTIVE

This is an interagency consultation pursuant to Section 7(a)(2) of the Endangered Species Act (ESA) and implementing regulations found at 50 CFR Part 402. The federal agencies that operate the Federal Columbia River Power System (FCRPS), namely the Bonneville Power Administration (BPA), the U.S. Army Corps of Engineers (Corps), and the U.S. Bureau of Reclamation (BOR) (collectively "the Action Agencies"), previously consulted with NMFS concerning the effects of the FCRPS on three listed species of Snake River salmon. NMFS concluded that consultation with its biological opinion and reasonable and prudent alternative (RPA) entitled “Reinitiation of Consultation on the 1994-1998 Operation of the FCRPS and Juvenile Transportation Program in 1995 and Future Years” issued on March 2, 1995 (hereafter referred to as the 1995 FCRPS Biological Opinion and the 1995 RPA). The Action Agencies have reinitiated that consultation to consider the effects of the FCRPS on recently listed species of anadromous fish, Snake River, Upper Columbia River, and Lower Columbia River steelhead. This document constitutes NMFS' Biological Opinion concerning these newly listed species. The objective of this consultation is to determine whether the operation of the FCRPS, as proposed by the Action Agencies and described in Section III (below), is likely to jeopardize the continued existence of the Snake River steelhead, Upper Columbia River steelhead, or Lower Columbia River steelhead.

At the same time, NMFS is considering in this supplemental opinion the status of the implementation of the 1995 RPA for listed Snake River chinook and sockeye. This is a periodic evaluation that NMFS and the Action Agencies have conducted according to the “framework” procedure called for by 1995 RPA measure 26 and as described in the letter of November 14, 1996, from NMFS to the Corps. In the framework analysis, NMFS determines whether implementation decisions made during the adaptive management process necessitate further consultation concerning these Snake River species. The current (1998) framework analysis is presented in Section VII of this supplemental Biological Opinion.

This Biological Opinion supplements the 1995 FCRPS Biological Opinion. The 1995 opinion, including its RPA and incidental take statement, shall continue in full effect except to the extent that the Action Agencies’ proposed action, as described in Section III (below) or this supplemental Biological Opinion, including its incidental take statement, changes particular measures in the 1995 opinion or establishes additional measures.

II. BACKGROUND

A. Events Leading to this Opinion

On March 2, 1995, NMFS issued the Endangered Species Act - Section 7 Consultation Biological Opinion titled "Reinitiation of Consultation on the 1995-1998 Operation of the Federal Columbia River Power System and Juvenile Transportation Program in 1995 and Future Years" (hereafter referred to as the 1995 FCRPS Biological Opinion). The previous FCRPS Biological Opinion was published by NMFS on March 2, 1995 (NMFS 1995). In that opinion, NMFS determined that the proposed action, described in the 1994 FCRPS Biological Opinion was likely to jeopardize the continued existence of listed spring/summer chinook salmon. The 1995 opinion set out the reasonable and prudent alternative to the proposed action which, with modifications described in a November 14, 1996, letter from W. Stelle (NMFS) to B. Bohn (Corps), hereafter referred to as the "framework" letter, was accepted by the Action Agencies and adopted in their respective Records of Decision.

The Snake River steelhead evolutionarily significant units (ESU) was listed as threatened and the Upper Columbia River steelhead ESU was listed as endangered on August 18, 1997. In a letter to Stelle (NMFS) on the same date, J. Velehradsky (Corps) requested a species list. Stelle provided the list to J. Velehradrasky, R. Hardy (BPA) and J. Keys (BOR) in a letter dated September 3, 1997, which directed all three Action Agencies to participate in discussions regarding the effects of the FCRPS on listed steelhead.

The Action Agencies transmitted their final "Biological Assessment for 1998 and Future Operation of the Federal Columbia River Power System, Upper Columbia and Lower Snake River Steelhead" (hereafter referred to as the Action Agencies' Biological Assessment) to NMFS on January 21, 1998. The Action Agencies clarified their proposed action in a letter from D. Geiger (Corps) to B. Brown dated February 12, 1998.

The NMFS initiated formal consultation with the Action Agencies and coordination with USFWS on February 4, 1998, and transmitted a draft supplemental Biological Opinion to these agencies on March 17, 1998 (letter from B. Brown [NMFS] to D. Arndt [Corps], R. McKown [BOR], D. Daley [BPA], and F. Olney [USFWS]). Based on further consultation with the Action Agencies and additional meetings with the salmon managers, NMFS revised the draft and transmitted the final supplemental Biological Opinion to the Action Agencies and USFWS on *[date to be determined]*. The species addressed in the draft and final supplemental opinions were the Snake and Upper Columbia River steelhead ESUs and the Lower Columbia River steelhead ESU. The NMFS determined the latter species to be "threatened" on March 13, 1998.

Also beginning on February 4, 1998, NMFS held a series of meetings with the non-federal salmon managers. These were coordinated through the Implementation Team and through the Columbia Basin Fish and Wildlife Authority (CBFWA) and included affected agencies and tribes who do not participate in the Regional Forum. During those meetings, the non-federal salmon managers commented on the technical elements of the proposed action. Beginning on February 27, 1998, open meetings were held with the Action Agencies and salmon managers together. The NMFS transmitted the draft supplemental Biological Opinion to the Implementation Team (IT) of the Regional Forum and the non-member tribes on March 19, 1998.

III. PROPOSED ACTION

A. Operation of the FCRPS by the Action Agencies (Corps, BPA, and BOR)

The primary action proposed in the Action Agencies' Biological Assessment is implementation of the reasonable and prudent alternative (RPA) of the 1995 FCRPS Biological Opinion, as adopted by the Action Agencies in their Records of Decision and as subsequently modified through the November 14, 1996, Framework letter from W. Stelle (NMFS) to B. Bohn (Corps).

The Biological Assessment also proposed additional actions and modifications of certain 1995 RPA measures for the purpose of maximizing transportation of listed Snake River steelhead and Upper Columbia River steelhead from collector projects (February 12, 1998, letter from D. Geiger [Corps] to B. Brown [NMFS]). These measures included curtailing voluntary spill at collector projects, transporting juveniles from McNary Dam during the spring migration, and allowing additional flexibility in reservoir elevations to control involuntary spill at collector projects.

During the consultation, the Independent Scientific Advisory Board (ISAB) released a review of scientific issues related to transportation, which included recommendations for the 1998 juvenile transportation program (ISAB 1998). The review stated, "The present mixed-stock truck and barge transportation system probably would improve survival for some affected populations, given the same in-river survival levels present during the NMFS studies. However, the effect of transportation on any particular population is unknown..." and "...the combined effects of collection and transportation may decrease survival for some populations, life history types and species." The conclusions and recommendations of the ISAB included: (1) employ a "spread the risk" approach to transportation in 1998 that ensures that the majority of the emigrants from any one stock is not transported and that uncollected emigrants are exposed to best possible in-river conditions; (2) eliminate the use of trucks in the transportation program; and (3) develop management actions for protecting salmon and steelhead at the population-specific level to the maximum extent possible; and (4) operate the hydrosystem in a manner that maximizes the survival of in-river migrants.

Based on the ISAB's recommendations, the Action Agencies and NMFS determined that it was not appropriate to maximize transportation at collector projects as originally proposed in the Biological Assessment. Therefore, the Action Agencies are considering their proposals to eliminate voluntary spill at Snake River collector projects and to allow greater fluctuations in reservoir elevations to reduce involuntary spill. Additionally, although NMFS and the Action Agencies agreed that transportation of a proportion of the Upper Columbia steelhead emigrants should occur from McNary Dam in order to "spread the risk" for this ESU, NMFS identified results of recent PIT-tag analyses, which suggest that there is a project-specific problem with collection and transportation of spring migrants from McNary Dam. Until this issue is resolved, following results of limited transportation of experimental groups from McNary Dam, after 1998, transportation of the run-at-large at McNary would not occur. An additional response to the ISAB report was to specify measures that would lead to a reduction in the proportion of the run that is transported from Snake River projects by truck during 1998 and to specify additional research to move towards an understanding of the effects of transportation on individual stocks.

The final elements of the proposed action, which either supplement or modify the 1995 RPA, are as follows:

1. Spring Flow Objectives for the Mid-Columbia River

Based on the best available information, NMFS believes that low river flows result in reduced survival of listed juvenile mid-Columbia steelhead and that establishment of flow objectives would help increase juvenile survivals; increased juvenile survivals potentially lead to increased adult returns in the long term. NMFS recognizes the lack of flow versus reach survival information relative to listed steelhead in the mid-Columbia, but believes that the available data, including those available elsewhere such as in the Snake River, support the designation of a mid-Columbia flow objective for steelhead. This flow objective is described in detail in Appendix A.

The Action Agencies are considering a proposal to improve flows in the mid-Columbia River through additional flow augmentation and to manage those flows on a weekly basis, in-season, to optimize fish survival. To provide additional volume during the spring outmigration and thereby assist in achieving improved flows, the Action Agencies are considering a proposal to operate the FCRPS in a manner that provides the same confidence of refill, as defined in the 1995 FCRPS Biological Opinion, to flood control elevation, or no more than 6 inches below that elevation, by April 10 each year at Grand Coulee.[1]

The NMFS' goal for operations in the mid-Columbia is to operate the FCRPS to match available water to fish movement during the spring and see that reservoirs are refilled by June 30 of each year. The actual timing of flow augmentation and the degree to which the June 30 refill objective is met would be determined by the TMT. The TMT, in recommending the shaping of flows in the mid-Columbia, would consider the desire to meet an average flow objective of 135 kcfs at Priest Rapids during the period April 10 through June 30, the desire to refill by June 30, timing, magnitude of the juvenile migration, water temperature, spill and total dissolved gas levels, adult fish and other requirements for improved survival of listed fish. The dates April 10 through June 30 are stated for planning purposes (Bickford 1996 and Fish Passage Center 1997).

The NMFS defines a seasonal flow objective as a guide to the in-season process and as a

[1] Due to construction activity at Grand Coulee Dam during winter 1998, the project is not expected to meet this or even the existing April 20th target for being at upper rule curve.

mechanism for comparing various operational scenarios (e.g., one scenario might give a 70 percent chance of meeting flow objectives while another gives a 50 percent chance). Given this definition, the 1995 FCRPS Biological Opinion and this supplemental Biological Opinion give general direction to the in-season management process on the factors to take into account in making flow augmentation decisions that would provide the greatest survivals for listed fish. The Biological Opinions do not require seasonal average flow objectives to be met weekly, nor do they suggest that flow augmentation can be stopped or diminished once a seasonal average has been met. Rather, the direction is to use the available augmentation to provide conditions that improve the survivals of listed fish throughout the season.

The TMT may consider and implement flows lower than the objective during the early part of the steelhead migration when fewer fish are present, particularly in low flow years. Flows greater than the objective may be provided on a weekly basis during key points in the migration, while acknowledging that lower flows would then need to occur later during the steelhead migration as a result of the desire to refill reservoirs by June 30 to provide flow augmentation for summer migrants.

In years when the April 1st, April-to-August 50 Percent Confidence Volume Forecast at The Dalles is less than average, the volume of water available for spring flow augmentation on both the Columbia and Snake Rivers would be constrained, as necessary, to achieve refill of reservoirs by June 30. That is, the use of available reservoir storage would be prioritized for summer migrants.

In addition, the Action Agencies are continuing to investigate the implementation of new flood control criteria called Variable Discharge (or VARQ) at Libby and Hungry Horse projects in coordination with the Regional Forum and the State of Montana, sovereign tribes, Northwest Power Planning Council, and other regional interests. Implementation of VARQ has the potential of improving winter reservoir conditions for resident fish and wildlife, and provide higher discharges in the spring for listed species. The investigation would include appropriate studies of local and system flood control, economic impacts, resident fish and wildlife, and proposed and listed species including white sturgeon, bull trout, steelhead, and chinook species. A status report on the progress of the studies would be completed by summer 1998. Prior to implementation, the Action Agencies would complete the appropriate NEPA and ESA documentation and would coordinate with Canada under the Columbia River Treaty.

2. Juvenile Fish Transportation

As described above, during consultation, NMFS and the Action Agencies responded to the recommendations of the ISAB (1998) by determining that it was appropriate to modify the transportation proposal in the Biological Assessment to a proposal which “spread-the-risk” of transportation and of in-river passage for each population of a listed ESU. Specific elements of the revised proposal for spring operations for the interim period include:

<u>Voluntary Spill at Snake River Collector Projects</u>: While NMFS was reviewing the transportation program (Appendix B) and developing a proposed action that would be consistent with the ISAB's (1998) "spread-the-risk" recommendation, it became apparent that there was an unexplained discrepancy in the definition of "low flow" levels that would trigger cessation of voluntary spill at Snake River collector projects. The "low flow" trigger was set at 85 kcfs at Little Goose and Lower Monumental Dams, but at 100 kcfs at Lower Granite Dam in 1995 RPA measure 2. Upon review, NMFS determined that there was no basis for the higher spill trigger at Lower Granite Dam and recommended that voluntary spill occur at all collector projects at flows above 85 kcfs (Appendix B). During consultation, the Action Agencies agreed to reconsider their proposal to include this recommendation. This would constitute a modification of 1995 RPA measure 2.

<u>Transportation of All Juveniles collected at each Snake River Collector Project</u>: All fish collected under this operation should be transported.

<u>Experimental Transportation from McNary Dam after 1998</u>: NMFS has determined that the moratorium on spring collection and transportation from McNary Dam adopted during 1995 should be continued and that maximum possible spill levels should be provided. NMFS has further determined that future research is needed on transport from McNary Dam, specifically on the response of Upper Columbia steelhead to transportation. Development and implementation of such research was considered for 1998, but was determined infeasible. By 1999, or at such time as a research plan is developed through the Regional Forum process, limited spring transport from McNary may occur for research purposes. Experimental transportation from McNary Dam, beginning in 1999 or later, would constitute a modification of 1995 RPA measure 4.

Once the problem described above has been identified and corrected, the goal of the interim program would be to transport a proportion of Upper Columbia River steelhead from McNary Dam.

No change is proposed in the use of juvenile fish transportation during the summer migration. As before, the transportation collector projects should be operated to maximize collection and transportation (i.e., no voluntary spill except as needed for approved research) during the summer migration.

<u>Truck Transportation</u>: With respect to the use of trucking, NMFS was surprised by the strength of the ISAB's recommendation and is still reviewing the information that was the basis of this conclusion. However, based solely on the high proportion of transported subyearling chinook

that are moved by trucks (average 92 percent, 1992 through 1996), NMFS shares the ISAB's concern. As a result, NMFS intends to continue to work with the ISAB and others to evaluate the potential for reduced risk through greater use of barging. Meanwhile, NMFS would also be working with the Corps and others through the Regional Forum to seek means of extending the use of barges, and thereby reduce the heavy reliance on trucking.

3. System Spill

The Action Agencies had proposed in their Biological Assessment to modify spill levels from those specified in 1995 RPA measure 2. The NMFS undertook a comprehensive review of new information affecting spill (Appendix C). This new information included better estimates of fish guidance efficiency (the proportion of juveniles approaching turbine intakes that are guided into bypasses), total dissolved gas levels associated with spill levels at each project, and new spill efficiency estimates at some projects (i.e., the proportion of fish approaching a project that pass via the spillway, divided by the proportion of total flow that is spilled). The NMFS review indicated that, while some projects were meeting the 80 percent fish passage efficiency goal (i.e., proportion of fish passage by non-turbine routes, others were not. Further, there were opportunities for additional increases in spill at some projects that would at least partially offset shortfalls in fish passage efficiency at others. In keeping with the purpose of the interim measures of the RPA to do everything possible to reduce FCRPS mortality prior to major structural changes, the Action Agencies are considering a proposal to spill to the levels specified below. This constitutes a modification to 1995 RPA measure 2, which only required spill to 80 percent fish passage efficiency at each project.

NMFS has determined that the 80 percent fish passage efficiency objective specified in the 1995 FCRPS Biological Opinion during the interim period (pending implementation of long-term recovery measures) should be revised to increase fish passage efficiency and survival on a system-wide basis. Rather than curtail spill at projects which meet the standard while continuing to miss the objective at other projects due to dissolved gas and other physical limits, the new standard should maximize spill to the extent possible given physical limits. The actual spill levels should be determined each year in the Water Management Plan developed through the Regional Forum. The actual dates of spill should be determined annually by the TMT based on in-season monitoring information. Planning dates are April 3 to June 20 and June 21 to August 31 for spring and summer, respectively, in the Snake River; April 10 to June 30 in the mid-Columbia River; and April 20[2] to June 30 and July 1 to August 31 for spring and summer, respectively, in the lower Columbia River. Initial estimated spill levels, and the basis for each, are provided

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[2] Review of steelhead passage information at McNary Dam indicated that the planning date of April 20 for chinook salmon is applicable to steelhead (Smolt Index Report, PIT-tag data, Fish Passage Center, Portland, Oregon). In some years, steelhead smolts reached McNary before April 20; in some years, after April 20.

below. Dissolved gas and biological monitoring information, and results of research on spill effectiveness and survival should be reviewed annually to develop specific spill levels for each project.

Project	Estimated Spill Level [3]	Hours	Limiting Factor
Lower Granite	45 kcfs	6 pm - 6 am	gas cap
Little Goose	60 kcfs	6 pm - 6 am	gas cap
Lower Monumental	40 kcfs	6 pm - 6 am	gas cap
Ice Harbor	75 kcfs (night) 45 kcfs (day)	24 hours	nighttime - gas cap daytime - adult passage
McNary	150 kcfs	6 pm - 6 am	gas cap
John Day	180 kcfs/60%[4]	1 hour before sunset to 1 hour after sunrise	gas cap/percentage
The Dalles	64%	24 hours	tailrace flow pattern and survival concerns (study planned in 1998)
Bonneville	120 kcfs (night) 75 kcfs (day)	24 hours	nighttime - gas cap daytime - adult fallback

Comparison of the old and new objectives is difficult because, whereas all were previously defined as a spill percentage, the newly proposed objectives (in most cases based on the gas caps) are described in terms of kcfs over the spillway. These changes are described in the appendix "Basis for NMFS Determinations Concerning the Use of Spill as Mitigation for Operation of the Federal

[3] Estimates of fish passage efficiency used to derive these spill levels were conservative in that they were based on the guidance efficiencies of hatchery spring/summer chinook rather than steelhead. The spill levels set in this supplemental opinion must be equally protective of the weakest listed stock present in the river during the steelhead outmigration period. The fish passage efficiency of summer chinook migrants would be even lower than that of hatchery spring/summer chinook.

[4] The total dissolved gas cap at John Day Dam is estimated at 180 kcfs and the spill cap for tailrace hydraulics is 60%. At project flows up to 300 kcfs, spill discharges will be 60% of instantaneous project flow. Above 300 kcfs project flow, spill discharges will be 180 kcfs (up to the hydraulic limit of the powerhouse).

Columbia River Power System" (attached) and briefly described for each project, below.

The specific spill volumes listed in the above table must be viewed as approximate "best cases" because the total dissolved gas levels measured at the monitoring sites below each project, at a given spill level, can vary with such factors as forebay dissolved gas level, spill patterns and water temperature changes. Also, there are many project-specific limitations on spill levels for reasons other than dissolved gas. These include adult passage, navigation, and research activities. These limitations are typically of short duration but they do reduce spill for fish passage to a limited degree. Specific recommendations and limitations for the system and each project are discussed below:

Lower Granite: At Lower Granite, the 1995 Biological Opinion spill level was 80 percent instantaneous spill for 12 hours per day. Under most conditions this level of spill could not be voluntarily implemented due to the gas cap of 40 kcfs. The Corps now estimates a gas cap of 45 kcfs at Lower Granite and this is the recommended limit except for the 0500 to 0600 hour when spill will be reduced to 25 kcfs to protect adult passage. A lower limit may need to be considered to accommodate safety concerns when the project is direct loading. At a river flow 100 kcfs, the new standard would provide an instantaneous spill level 45 kcfs and an estimated fish passage efficiency (FPE) of 85 percent.

Little Goose: At Little Goose the 1995 Biological Opinion spill level was 80 percent instantaneous spill for 12 hours per day. As at Lower Granite Dam, this level could usually not be voluntarily implemented due to a gas cap of about 35 kcfs. The Corps now estimates a gas cap of 60 kcfs at this dam and this is the recommended limit except for the 0500 to 0600 hour when spill will be reduced to 25 kcfs to protect adult passage. At a river flow 100 kcfs, the new standard would provide an instantaneous spill level of 60 kcfs and an estimated of FPE 86 percent.

Lower Monumental: At Lower Monumental the 1995 Biological Opinion spill level was 81 percent of instantaneous spill for 12 hours per day. Again, this level of spill was not voluntarily provided because of a gas cap of about 40 kcfs. The Corps has not changed this gas cap, therefore, spill levels at this dam would probably not change in 1998. Because of the limited spill, achievable FPE would be limited to an estimated 61 percent.

Ice Harbor: The Ice Harbor spill level in the 1995 Biological Opinion was 27 percent in the spring and 70 percent in the summer, 24 hours per day. A gas cap of about 25 kcfs limited voluntary spill, however, the 27 percent target was achieved much of the time. The summer target of 70 percent was achieved at the lower flow levels. Due to installation of spillway flow deflectors, the Corps now estimates the gas cap at 75 kcfs and the gas cap is the recommended limit. Concerns for adult passage would limit daytime (0500 to 1800) spill to 45 kcfs. Additional short-term limits may need to be imposed to address safety concerns when barges are exiting the lock in the downstream direction. At a river flow of 100 kcfs, the new standard would provide an instantaneous spill level of 75 kcfs and an estimated spring chinook FPE of 84 percent.

McNary: At McNary Dam the 1995 Biological Opinion spill level was 50 percent for 12 hours per day. The gas cap of 120 kcfs and the limited powerhouse capacity allowed spill levels at the 1995 Biological Opinion percentages under most conditions. The Corps now estimates a gas cap of 150 kcfs at this dam and the gas cap is the recommended limit. At a river flow of 240 kcfs, the new standard would provide an instantaneous spill level of 150 kcfs and an estimated FPE of 89 percent.

John Day: At John Day Dam the 1995 Biological Opinion spring spill level was 33 percent in the spring and 86 percent in the summer, 12 hours per day. The gas cap of 20 to 50 kcfs (depending on spill pattern) did not allow voluntary spill to the 1995 Biological Opinion levels under most river flows. Because of the completion of spill flow deflectors at this project, the Corps now estimates a new gas cap at about 180 kcfs. This is the recommended limit except when river flows are below about 250 to 300 kcfs. At this flow, poor tailrace conditions at the bypass outfall would limit spill to 60 percent of the total river flow. This flow trigger is still under investigation and may change slightly before the 1998 season. At a river flow of 240 kcfs, the new standard would provide an instantaneous spill level of 60 percent and an estimated spring chinook FPE of 79 percent, from one hour before sunset to one hour after sunrise. A change in hours is also being considered to one hour before sunset to one hour after sunrise.

Spill at John Day Dam will increase in 1998 due to completion of spillway flow deflectors in late 1997. Twenty-four hour spill would be investigated during 1999. High spillway effectiveness and high daytime passage was noted during 24 hour spill in 1997 (Corps memo, February 3, 1998). Effectiveness was highest during the summer but daytime passage was much higher than expected in both spring and summer, indicating a potential decrease in forebay residence time and subsequent predator exposure in this area.

The Dalles: The 1995 Biological Opinion spill level at The Dalles Dam was 64 percent for 24 hours. Because the gas cap was 230 kcfs, the Opinion spill level was met most of the time. While it is possible to increase spill to the gas cap, poor tailrace conditions and recent poor survival estimates at high spill volumes are a concern. No change is recommended until planned survival and spill effectiveness research, planned for 1998, can be completed. Changes in spill operations at The Dalles may be recommended once the research is completed. At a river flow of 240 kcfs, 64 percent spill would provide an estimated FPE of 79 percent.

Bonneville: The 1995 Biological Opinion did not recommend specific spill percentages at Bonneville Dam because the daytime spill cap to limit adult fallback and the gas cap of 120 kcfs limit spill severely. Research is necessary to address these issues. No change in spill is recommended at this time. At a 240 kcfs river flow, the limited spill would provide an estimated FPE of 59 percent.

4. Feasibility Studies for Alternative System Configurations in the Lower Columbia River

The Action Agencies are considering a proposal to continue to investigate surface bypass technology, guidance efficiency improvements, and other system improvements at Bonneville, The Dalles, John Day and McNary Dams, and to integrate this information into a comprehensive feasibility study for the long-term configuration of the lower Columbia River reach (Lower Columbia River System Configuration Study). The objective of the study would be to complete comprehensive scoping, feasibility, design, and engineering work for potential alternative configurations of lower Columbia River projects that would improve the survival of proposed and listed anadromous species. As an initial step, the Action Agencies are considering a proposal to work through the Regional Forum process to develop biological goals for the lower Columbia River reach. The biological goals would be used to formulate and select alternatives, including specific flow augmentation operations, for further detailed study. At a minimum, the alternatives would include:

Drawdown: A scoping document for John Day Drawdown Study was prepared by the Corps during late 1997 and early 1998. It was transmitted, on February 12, 1998, to congressional committees via the FY 1998 Energy and Water Development Appropriations Bill. If the Corps receives congressional direction to evaluate drawdown at John Day, the evaluation would include both spillway crest and natural river level drawdown, as identified in the scoping document.

In the ISAB's 1996 report "Return to the River", drawdown at the McNary project was discussed as a potential measure to improve the survival of anadromous species. Study of McNary drawdown is not part of the proposed FY 1999 budget, nor has the scope of McNary drawdown been discussed in the Regional Forum process. Prior to initiating any study of McNary drawdown, the Corps would notify the appropriate congressional committees and would initiate discussion in the Regional Forum process. If congressional appropriations permit, the evaluations at McNary would include drawdown to natural river level.

Maximum Spill: The Action Agencies are considering a proposal to evaluate a maximum spill with gas abatement alternative to determine the potential to implement a major improvement in survival through the four lower river projects without drawdown. In field evaluations, spill has consistently provided maximum juvenile migrant survival past dams relative to other routes of passage. However, the adverse effects of dissolved gas and the effects on adult fishway entrance requirements and tailrace hydraulic patterns on adult and juvenile migrants limit the amount of water that can be spilled. Selection of a maximum spill alternative would therefore consider a broad range of potential project modifications to address these considerations while maximizing spillway passage. This information would be incorporated into the on-going Gas Abatement Study.

<u>Full Flow Bypass</u>: The Action Agencies are considering a proposal to evaluate juvenile bypass outfall criteria and, based on research findings, to develop appropriate criteria for potential full-flow bypass of juvenile salmonids without any handling.

<u>Surface Bypass Collection</u>: The Action Agencies are considering a proposal to evaluate surface bypass collection alternatives including the on-going evaluations of skeleton bays at John Day Dam, the surface bypass prototype at Bonneville Dam First Powerhouse, and surface bypass options at The Dalles Dam. Further application of surface bypass collection and physical guidance devices at all four lower Columbia River projects would also be evaluated.

<u>Improved Transportation</u>: The Action Agencies are considering a proposal to evaluate structural and operational alternatives to improve juvenile transportation at McNary. These alternatives could include the construction of additional barges to expand the capacity for direct loading or improvements to the juvenile bypass system.

<u>Other System Improvements</u>: The Action Agencies are considering a proposal to continue the on-going evaluations of fish guidance efficiency improvements at Bonneville Dam First and Second Powerhouses, and relocation of the ice and trash sluiceway outfall. The deferred design of the mechanical bypass system at The Dalles, and other juvenile bypass improvements would be included in the comprehensive analysis. The following specific actions would be evaluated for Bonneville Dam: (1) improvements in fish guidance efficiency, (2) the ability to operate the Second Powerhouse independently from the First Powerhouse, (3) structural and operational modifications to reduce fallback (e.g., modifications to adult passage facilities), and (4) turbine modifications (intake to draft tube exit) that would improve fish passage survival.

Results and recommendations from the Lower Snake River Final Feasibility Study scheduled for completion in late 1999 would be considered in selecting alternatives for further detailed studies. A status report of the preliminary engineering studies and biological evaluations, that narrows down the alternatives for each project in the lower Columbia River reach, would be completed by mid-2000. The final feasibility study would include the appropriate NEPA and ESA documentation and if necessary, recommendations to Congress for authorization and implementation of a selected plan for the lower Columbia River reach by 2004.

5. Analytical Techniques and Data for Consultation on Long-term Operations of the FCRPS

The Action Agencies are considering funding for a regionally-coordinated analysis, through a forum such as the Plan for Analyzing and Testing Hypotheses (PATH), to determine effects of the proposed actions within the context of species-level biological requirements of listed steelhead ESUs. This analysis would be completed by December 1999, so that it can be applied in future FCRPS consultations following the 1999 decision regarding operation of the FCRPS on the Snake River and following a later decision regarding the operation of lower Columbia River projects.

Section V of this Biological Opinion describes the absence of tools for analyzing effects of proposed actions within the context of the entire life-history of listed steelhead ESUs. Interim analytical techniques were employed to assess effects of the proposed action on species-level biological requirements of Snake River steelhead and Upper Columbia River steelhead, but these techniques need to be validated and improved upon through a more detailed analytical effort. Further, it was not possible to develop even interim techniques for Lower Columbia River steelhead for this Biological Opinion, so the development of methods specific to this ESU are critical. Development of these techniques by December 1999 should allow completion of a biological opinion addressing long-term operation of the FCRPS in 2000 and future years.

B. Issuance of Section 10 Permits by NMFS

1. Modification of the Section 10 Permit for the Juvenile Transportation Program

The Corps of Engineers, Walla Walla District, applied to NMFS for a modification of Permit 895 under authority of section 10 of the ESA and the NMFS regulations governing ESA-listed fish and wildlife permits (50 CFR parts 217 through 227). Permit 895 authorizes the Corps annual direct takes of juvenile, endangered Snake River sockeye salmon (Oncorhynchus nerka); juvenile, threatened, naturally-produced and artificially-propagated, Snake River spring/summer chinook salmon (O. tshawytscha); and juvenile, threatened, Snake River fall chinook salmon (O. tshawytscha) associated with the Corps' juvenile fish transportation program at four hydroelectric projects on the Snake and Columbia Rivers (Lower Granite, Little Goose, Lower Monumental, and McNary Dams). Permit 895 also authorizes the Corps' annual incidental takes of ESA-listed adult fish associated with fallbacks through the juvenile fish bypass systems at the four dams.

For modification 4 to the permit, the Corps requests (1) annual direct takes of juvenile, endangered, naturally-produced and artificially-propagated, upper Columbia River steelhead (Oncorhynchus mykiss) and juvenile, threatened, Snake River steelhead (Oncorhynchus mykiss) associated with the transportation program and (2) annual incidental takes of ESA-listed adult steelhead associated with fallbacks through the juvenile bypass system. ESA-listed steelhead indirect and incidental mortalities associated with the transportation program are requested. Also for modification 4, the Corps requests and extension of the expiration date of permit 895 to December 31, 1999. Permit 895 is currently due to expire on December 31, 1998. The Corps is conducting a feasibility study to evaluate several alternatives to juvenile fish transport which is scheduled to be completed by late 1999. An extension of permit 895 through December 31, 1999, would allow the duration of the permit to coincide with the completion of the feasibility study.

The public comment period on the Corps' permit application ends March 27, 1998. The NMFS expects to issue the requested modification to Permit 895 within 7 to 10 days after the end of the comment period.

2. Modification of the Section 10 Permit for the Smolt Monitoring Program

The Fish Passage Center (FPC) has applied to NMFS for a modification to Permit 822 which authorizes the FPC annual direct takes of juvenile, endangered Snake River sockeye salmon (Oncorhynchus nerka); juvenile, threatened, naturally-produced and artificially-propagated, Snake River spring/summer chinook salmon (O. tshawytscha); and juvenile, threatened, Snake River fall chinook salmon (O. tshawytscha) associated with the Smolt Monitoring Program conducted at hydropower dams on the Snake and Columbia Rivers and a number of upriver locations in the state of Idaho. Permit 822 also authorizes the FPC annual incidental takes of ESA-listed adult Snake River salmon associated with fallbacks through the juvenile bypass systems at Bonneville and John Day Dams on the Columbia River.

For modification 5 to the permit, the FPC requests (1) annual direct takes of juvenile, endangered, naturally-produced and artificially-propagated, upper Columbia River steelhead (Oncorhynchus mykiss) and juvenile, threatened, Snake River steelhead (Oncorhynchus mykiss) associated with the SMP; (2) an annual direct take of juvenile lower Columbia River steelhead (Oncorhynchus mykiss), a species currently proposed as threatened, at Bonneville Dam; and (3) annual incidental takes of ESA-listed adult steelhead associated with fallbacks through the juvenile bypass systems at Bonneville and John Day Dams. ESA-listed steelhead indirect and incidental mortalities associated with the SMP are requested. Modification 5 to Permit 822 is request to be valid for the duration of the permit. Permit 822 is currently due to expire on December 31, 1998. The Corps is conducting a feasibility study to evaluate several alternatives to juvenile fish transport which is scheduled to be completed by late 1999. An extension of permit 895 through December 31, 1999, would allow the duration of the permit to coincide with the completion of the feasibility study.

The public comment period on the FPC's permit application ends April 6, 1998. The NMFS expects to issue the requested modification to Permit 822 within 7 to 10 days after the end of the comment period.

C. Duration of the Proposed Actions

The duration of the proposed actions would be coincident with the interim period described in the 1995 FCRPS Biological Opinion. It is likely that, at the time when a decision is made for the long-term operation of FCRPS projects on the lower Snake River (scheduled for late 1999), new information made available by that process would trigger reinitiation of consultation on the effects of the FCRPS on the Upper and Lower Columbia River steelhead ESUs. In addition, consultation on the Section 10 permits for the Juvenile Transportation Program and the Smolt Monitoring Program would be reinitiated.

IV. BIOLOGICAL INFORMATION

A. List of species

1. Snake River Steelhead

The NMFS listed this inland steelhead ESU, occupies the Snake River Basin of southeast Washington, northeast Oregon, and Idaho, as threatened on August 18, 1997 (62 FR 43937). The Snake River flows through terrain that is warmer and drier on an annual basis than the upper Columbia Basin or other drainages to the north. Collectively, these environmental factors result in a river that is warmer and more turbid, with higher pH and alkalinity, than is found elsewhere within the range of inland steelhead.

Snake River Basin steelhead, like most inland steelhead, are summer-run. Two groups, A-run and B-run, are defined based on the timing of their respective adult migrations, ocean-age, and size at maturity. Snake River Basin steelhead enter fresh water from June to October and spawn in the following spring from March to May. A-run steelhead are thought to be predominately l-ocean, while B-run steelhead are thought to be 2-ocean (IDFG 1994). Snake River Basin steelhead usually smolt at age-2 or -3 years (Whitt 1954; BPA 1992; Hassemer 1992).

Run-timing separation is not observed once the Snake River run is above Bonneville Dam. Above this point, the groups are separated by ocean age and body size (IDFG 1994). It is unclear if the life history and body size differences observed upstream can be correlated with the groups that form the bimodal migration observed at Bonneville Dam. Furthermore, the relationship between patterns observed at the dams and the distribution of adults in spawning areas through the Snake River basin is not well understood.

2. Upper Columbia River Steelhead

This inland steelhead ESU occupies the Columbia River Basin upstream from the Yakima River, Washington, to the United States' border with Canada. NMFS listed the Upper Columbia River ESU as endangered on August 18, 1997 (62 FR 43937). The geographic area occupied by this ESU forms part of the larger Columbia Basin Ecoregion (Omernik 1987). The Wenatchee and Entiat Rivers are in the Northern Cascades Physiographic Province and the Okanogan and Methow Rivers are in the Okanogan Highlands Physiographic Province. Mullan et al. (1992), describing this area as a harsh environment for fish, stated that "it should not be confused with more studied, benign, coastal streams of the Pacific Northwest."

Life history characteristics for Upper Columbia River Basin steelhead are similar to those of other inland steelhead ESUs; however, some of the oldest smolt ages for steelhead, up to 7 years, are reported from this ESU. Mullen et al. (1992) suggested that this longevity may be associated with cold stream temperatures. Based on the limited data available, smolt age in this ESU is dominated by two-year-olds. Steelhead from the Wenatchee and Entiat Rivers return to fresh water after one year in salt water, whereas Methow River steelhead are primarily 2-ocean resident (Howell et al. 1985).

In 1939, the construction of Grand Coulee Dam on the Columbia River (RKm 956) blocked over 1,800 km of river from access by anadromous fish (Mullan et al. 1992). During 1939 through 1943, in an effort to preserve fish runs affected by Grand Coulee Dam, all anadromous upstream migrants were trapped at Rock Island Dam (RKm 729) and either released to spawn in tributaries between Rock Island and Grand Coulee Dams or spawned in hatcheries and the offspring were released in that area (Peven 1990; Mullan et al. 1992; and Chapman et al. 1994). Through this process, stocks of all anadromous salmonids, including steelhead, which historically were native to several separate subbasins above Rock Island Dam, were redistributed among tributaries in the Rock Island-Grand Coulee reach. The degree and manner in which this action has affected the genetic composition of steelhead stocks that currently spawn in the wild is unknown.

3. Lower Columbia River Steelhead

This coastal steelhead ESU occupies tributaries to the Columbia River between the Cowlitz and Wind Rivers in Washington, inclusive, and the Willamette and Hood Rivers in Oregon, inclusive. Excluded are steelhead in the upper Willamette River Basin above Willamette Falls, and steelhead from the Little and Big White Salmon Rivers in Washington. The NMFS listed these fish as threatened on [FR citation pending].

Steelhead populations in this ESU are of the coastal genetic group (Schreck et al. 1986, Reisenbichler et al. 1992, and Chapman et al. 1994). A number of genetic studies have shown that they are part of a different ancestral lineage than inland steelhead from the Columbia River Basin. Genetic data also show steelhead from this ESU to be distinct from steelhead from the upper Willamette River and coastal streams in Oregon and Washington. Data developed by the Washington Department of Fish and Wildlife show genetic affinities between Kalama, Wind, and Washougal River steelhead. These data show differentiation between the Lower Columbia River ESU and the Southwest Washington and Middle Columbia River Basin ESUs. This ESU is composed of winter steelhead and summer steelhead.

B. Species Life Histories and Historical Population Trends

Steelhead exhibit one of the most complex life histories of any salmonid species. Steelhead may exhibit anadromy (i.e., migrate as juveniles from fresh water to the ocean and then return to spawn in fresh water) or freshwater residency (reside their entire life in fresh water). Resident forms are usually referred to as "rainbow" or "redband" trout, while anadromous life forms are termed "steelhead." Because few detailed studies have been conducted regarding the relationship between resident and anadromous O. mykiss, the relationship between these two life forms is poorly understood.

Steelhead typically migrate to marine waters after spending 2 years in fresh water. They then reside in marine waters for 2 or 3 years prior to returning to their natal stream to spawn as 4- or 5-year-olds. Unlike Pacific salmon, steelhead are iteroparous, meaning they are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying and most that do so are females. Steelhead adults typically spawn between December and June (Bell 1990 and Busby et al. 1996). Depending on water temperature, steelhead eggs may incubate in "redds" (nesting gravels) for 1.5 to 4 months before hatching as "alevins" (a larval life stage dependent on food stored in a yolk sac). Following yolk sac absorption, alevins emerge from the gravel as young juveniles or "fry" and begin actively feeding. Juveniles rear in fresh water for 1 to 4 years, then migrate to the ocean as "smolts."

Biologically, steelhead can be divided into two reproductive ecotypes, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration. These two ecotypes are termed "stream maturing" and "ocean maturing." Stream maturing steelhead enter fresh water in a sexually immature condition and require several months to mature and spawn. Ocean maturing steelhead enter fresh water with well-developed gonads and spawn shortly after river entry. These two reproductive ecotypes are more commonly referred to by their season of freshwater entry (e.g., summer and winter steelhead).

Two major genetic groups or "subspecies" of steelhead occur on the west coast of the United States: a coastal group and an inland group, separated in the Fraser and Columbia River Basins by the Cascade crest approximately (Huzyk & Tsuyuki 1974: Allendorf 1975; Utter & Allendorf 1977; Okazaki 1984; Parkinson 1984; Schreck et al. 1986; Reisenbichler et al. 1992). Both coastal and inland steelhead occur in Washington and Oregon. California is thought to have only coastal steelhead while Idaho has only inland steelhead.

Historically, steelhead were distributed throughout the North Pacific Ocean from the Kamchatka Peninsula in Asia to the northern Baja Peninsula. Presently, the species distribution extends from the Kamchatka Peninsula, east and south along the Pacific coast of North America, to at least Malibu Creek in southern California. There are infrequent anecdotal reports of steelhead continuing to occur as far south as the Santa Margarita River in San Diego County (McEwan & Jackson 1996). Historically, steelhead probably inhabited most coastal streams in Washington, Oregon, and California as well as many inland streams in these states and Idaho. However, during this century, over 23 indigenous, naturally-reproducing stocks of steelhead are believed to have been extirpated, and many more are thought to be in decline in numerous coastal and inland streams in Washington, Oregon, Idaho, and California. Forty-three stocks have been identified by Nehlsen et al. (1991) as being at moderate or high risk of extinction.

V. EVALUATING PROPOSED ACTIONS

In the March 2, 1995, Biological Opinion (1995 FCRPS Biological Opinion) regarding operation of the Federal Columbia River Power System (FCRPS), the National Marine Fisheries Service (NMFS) described a five-part approach to applying the jeopardy standards in the Endangered Species Act (ESA) implementing regulations to Pacific salmon. The same general approach is applied to listed steelhead in this biological opinion. This analysis involves the following steps:

(1) define the biological requirements of the listed species;

(2) evaluate the relevance of the environmental baseline to the species' current status;

(3) determine the effects of the proposed or continuing action on listed species;

(4) determine whether the species can be expected to survive with an adequate potential for recovery under the effects of the proposed or continuing action, the environmental baseline and any cumulative effects, and considering measures for survival and recovery specific to other life stages; and

(5) identify reasonable and prudent alternatives to a proposed or continuing action that is likely to jeopardize the continued existence of the listed species.

Details regarding each step follow.

V.A. Biological Requirements For Listed Species

V.A.1. Biological Requirements Within the Action Area

V.A.1.a. Snake River Steelhead

The action area relative to Snake River steelhead is the Snake/Columbia River migration corridor from the most upstream points at which listed steelhead are affected by federal water management (mainstem Snake River below Hells Canyon complex; lower Clearwater River below Dworshak Dam) to the most downstream points influenced by federal water management (Columbia River plume and nearshore ocean environment).

It is reasonable to assume that the biological requirements of juvenile Snake River steelhead within the action area are very similar to those of other juvenile salmonids in the Snake River and Columbia River migration corridor. These biological requirements stem from the essential features of the juvenile migration corridor, as described in the critical habitat designation for Snake River spring/summer chinook salmon, fall chinook salmon, and sockeye salmon (58 FR

68543). Therefore, the biological requirements of juvenile Snake River steelhead include: (1) adequate substrate; (2) adequate water quality; (3) adequate water quantity; (4) adequate water temperature; (5) adequate water velocity; (6) adequate cover and shelter; (7) adequate food; (8) adequate riparian vegetation; (9) adequate space; and (10) safe passage conditions.

It is reasonable to assume that biological requirements of adult Snake River steelhead within the action area are very similar to those of other adult salmonids in the Snake River and Columbia River migration corridor. These requirements are the same as those described for juveniles, with the exclusion of (7) adequate food.

V.A.1.b. Upper Columbia River Steelhead

The action area relative to Upper Columbia River steelhead is the Columbia River migration corridor from the most upstream point at which listed steelhead are affected by federal water management (mainstem Columbia River below Chief Joseph Dam) to the most downstream point influenced by federal water management (Columbia River plume and nearshore ocean environment).

The biological requirements of adult and juvenile Upper Columbia River steelhead are the same as those described for Snake River steelhead.

V.A.1.c. Lower Columbia River Steelhead

The action area relative to Lower Columbia River steelhead is the Columbia River migration corridor from the most upstream point at which listed steelhead are affected by federal water management (mainstem Columbia River below the Hood River and the Wind River in Bonneville reservoir) to the most downstream point influenced by federal water management (Columbia River plume and nearshore ocean environment).

The biological requirements of adult and juvenile Lower Columbia River steelhead are the same as those described for Snake River steelhead.

V.A.2 Biological Requirements That Apply to All Actions and Action Areas

V.A.2.a. Snake River Steelhead

At the species level, steelhead biological requirements are population numbers, trends, geographic distribution, and genetic variability sufficient to ensure survival with an adequate potential for recovery. Survival and recovery are defined as in previous NMFS and USFWS documents:

Survival: the species' persistence, beyond conditions leading to its endangerment, with sufficient resilience to allow recovery. Said another way, survival is the condition in which a species continues to exist into the future while retaining the potential for recovery. This condition is characterized by a species with a sufficiently large population, represented by all age classes, genetic heterogeneity, and a number of sexually mature individuals producing viable offspring, that exists in an environment providing all requirements for completion of the species' entire life cycle, including reproduction, sustenance, and shelter.

Recovery: improvement in the status of a species and the ecosystems upon which they depend. Said another way, recovery is the process by which species' ecosystems are restored so they it can support self-sustaining and self-regulating populations of listed species as persistent members of native biotic communities.

Knowledge of the species-level biological requirements allows assessment of the “adequacy” of the action-area biological requirements (as listed in Section V.A.1.a) within the context of the full life cycle. This “adequacy” is a function of both the life history of the stock under consideration and the current status of that stock. For example, populations of stream-type chinook salmon, which experience relatively high tributary mortality during extended freshwater rearing and pass through the migration corridor at a relatively large size, may be expected to experience lower total migration corridor mortality under natural conditions than do ocean-type chinook salmon, which experience lower tributary mortality during the short period prior to emigration and pass through the migration corridor at a smaller size. Overall, each life history type has similar general biological requirements in each life-history stage, but the distribution of mortality among those stages can be expected to differ among the stocks. Similarly, a stock with abundance near the theoretical maximum sustainable production level is likely to be able to sustain greater migration corridor mortality caused by human actions than can a stock that is at very low population levels.

In the 1995 FCRPS Biological Opinion, definition of species-level biological requirements for Snake River chinook salmon relied upon estimation of: (1) “threshold” stock-specific spawner abundance levels required for continued survival of at least several representative populations comprising the evolutionarily significant unit (ESU) and (2) recovery population levels. There are several problems with applying these Snake River chinook population levels to Snake River steelhead species-level biological requirements at this time. For example, “threshold” levels for Snake River chinook were defined at least partially by levels at which population simulation model behavior was uncertain and such simulation models currently do not exist for Snake River steelhead. Also, recovery population levels associated with delisting Snake River chinook were developed by the Snake River Recovery Team and NMFS following a multi-year process. Recovery population levels for Snake River steelhead have not yet been defined. It is possible that threshold values will be suggested through the multi-agency Plan for Analyzing and Testing Hypotheses (PATH) process, in which case these estimates will become available during late 1998 or 1999. Recovery levels are unlikely to be defined until NMFS develops proposed delisting criteria, which may take several years.

Until the PATH analysis is complete and recovery levels are defined, NMFS intends to apply an interim performance index, which is believed to be indicative of survival and recovery. This interim performance measure is currently being developed in cooperation with the PATH process. The performance measure is:

Historical Smolt-to-Adult Return Rates (SAR): PATH has suggested a correspondence between 2 to 6 percent SARs of aggregate Snake River spring/summer chinook salmon stocks during the 1960s, when these stocks appeared to be experiencing high survival and were at or near the proposed recovery levels, and the ability of the stocks to persist and recover (Chapter 6 in Marmorek et al. 1996). The 2 to 6 percent goal was based on several factors. The factor with the greatest potential for Snake River steelhead was use of SAR/(1-Harvest) estimates of Raymond (1988), multiplied by (1- average harvest rates during the 1960's) to provide estimates of actual survival rates to the upper dam. This method yielded estimates of 2 to 4 percent SAR for spring chinook and 2 to 5 percent SAR for summer chinook (Chapter 6 of Marmorek et al. 1996). A subcommittee of PATH is currently attempting to determine the specific SARs to the upper dam using a more explicit methodology than that applied in Chapter 6 of Marmorek et al. (1996), and which can be applied to other species. **Preliminary estimates for the 1964 through 1969 Snake River spring/summer chinook SAR to the upper dam range from 2.1 to 3.8 percent, with a geometric mean of 2.8 percent (Petrosky and Schaller 1998 - DRAFT). These numbers are subject to change.**

PATH is currently attempting to validate the target chinook SAR by evaluating its correspondence to more complex estimates of survival and recovery. Preliminary PATH analyses indicate that a SAR of 2 to 7 percent is associated with model runs that meet NMFS' jeopardy standard for achieving recovery (i.e., "moderate to high likelihood" [interpreted as $\geq$50 percent probability] that 80 percent of spring/summer chinook stocks will achieve recovery spawner levels on average during the 8-year period ending 48 years in the future) (Marmorek and Peters 1998 - DRAFT). Analyses that will determine the correspondence of SARs with acceptable probabilities of being above threshold levels have not yet been completed.

Given that historical Snake River spring/summer chinook SARs can be used as a proxy for acceptable probabilities of being above population threshold levels and reaching recovery levels within a reasonable period of time, it is reasonable to assume that the same approach can be applied to other listed species. It is possible to estimate historical SARs for Snake River steelhead using comparable methods. **Preliminary estimates for 1964 through 1969 Snake River steelhead SAR to the upper dam range from 3.4 to 4.2 percent, with a geometric mean of 3.8 percent (Petrosky 1998 - DRAFT). These estimates are subject to change.**

[Note: Tribal PATH representative strongly objects to determining necessary SAR based on the number of fish actually passing the upper dam during the historical period when stocks had high SAR, high harvest rates, and were at or near recovery levels. He suggests that the necessary SARs be increased proportional to the historical harvest rates, to ensure

that the survival and recovery goal includes a harvest potential comparable to that occurring historically. The preliminary estimates of the 1964 through 1969 Snake River steelhead SAR range estimated in this manner is 4.5 to 6.3 percent, with a geometric mean of 5.6%. The corresponding range for preliminary estimates of Snake River historical spring/summer chinook SAR is 3.9 to 6.2 percent, with a geometric mean of 4.8%. These numbers are subject to change.]

[Note: Idaho PATH representative objects to determining necessary SAR based on aggregate Snake River steelhead run. He proposes breaking this into A-run and B-run SARs and has proposed a method for doing so that may be possible to implement in time for the final biological opinion. It is not available at present.]

Following completion of the PATH analysis or draft recovery planning process, results will be reviewed and, if the new information suggests that the above description of species-level biological requirements for Snake River steelhead is inadequate, reinitiation of consultation may be necessary.

V.A.2.b. Upper Columbia River Steelhead

The same constraints to identifying Snake River steelhead species-level biological requirements apply to identification of Upper Columbia River steelhead.

An interim approach using the SAR methodology described in Section V.A.2.a is currently being applied to Upper Columbia River steelhead. Preliminary estimates for 1964 through 1969 Upper Columbia River steelhead SAR range from 1.7 to 2.9 percent, with a geometric mean of 2.2 percent (Cooney 1998 - DRAFT). These estimates are subject to change.

Following completion of the PATH analysis or draft recovery planning process, results will be reviewed and, if the new information suggests that the above description of species-level biological requirements for Snake River steelhead is inadequate, reinitiation of consultation may be necessary.

V.A.2.c. Lower Columbia River Steelhead

The same constraints to identifying Snake River steelhead species-level biological requirements apply to identification of Upper Columbia River steelhead.

At this time a quantitative approach has not been defined by NMFS or PATH scientists. There is a strong likelihood that a quantitative definition of species-level requirements will not be available for this ESU for the current consultation and assessment of species-level biological requirements may be qualitative considerations of factors such as the relative significance of FCRPS mortality on this species, compared to other species.

Following completion of the PATH analysis or draft recovery planning process, results will be reviewed and, if the new information suggests that the above description of species-level biological requirements for Snake River steelhead is inadequate, reinitiation of consultation may be necessary.

V.B. Relevance of the Environmental Baseline To the Species' Current Status

The biological requirements of Snake River steelhead, Upper Columbia River steelhead, and Lower Columbia River steelhead - do we need different wording for the proposed species are currently not being met under the environmental baseline, which is apparent from the species' declining status in recent years (Busby et al. 1996). This trend was based on adult returns through 1994, which means it was based on juvenile migrations through about 1992. Updated information through the 1996 adult returns (approximately 1994 juvenile migration) indicates that the declining trend has continued and the environmental baseline is still detrimental (West Coast Steelhead Biological Review Team 1997; Schiewe 1997a). Any further degradation of these conditions would have a significant impact due to the amount of risk the listed salmon presently face under the environmental baseline.

Additional reductions in human-induced mortality, beyond those in place at the time of listing, are necessary to improve the environmental baseline. In the absence of allocation of mortality reduction among the various human impacts through a recovery plan, reductions in each major area of human-induced mortality are necessary to avoid jeopardy. For FCRPS hydrosystem-related mortality, until adult returns from outmigrations since 1995 are complete, it is not possible to fully assess the extent of beneficial effects associated with the interim action. Future actions that are expected to reduce mortality from the level associated with the environmental baseline include post-1999 long-term actions in the 1995 FCRPS Biological Opinion's reasonable and prudent alternative (RPA). Indefinite continuation of the interim action in place at the time of listing is not expected to improve the environmental baseline sufficiently to avoid jeopardy.

V.C. Determining the Effects of the Proposed or Continuing Actions on Listed Species.

Mortality and sublethal effects (e.g., changes in migration timing or speed) associated with water management, river impoundment, dam passage, transportation, and other aspects of FCRPS operation are described in Section VI. That section also describes how these effects are expected to change over time with full implementation of the RPA.

V.D. Likelihood That the Species Can Be Expected to Survive With an Adequate Potential For Recovery Under the Effects of the Proposed or Continuing Action, the Environmental Baseline and Any Cumulative Effects, and Considering Measures For Survival and Recovery Specific to Other Life Stages

V.D.1. Determine Significance of the Aggregate Effect Upon the Particular Biological Requirements of the Listed Species In the Action Area

V.D.1.a. Snake River Steelhead

Because Snake River steelhead action-area biological requirements are assumed to be equivalent to Snake River chinook action-area biological requirements (Section V.A.1.a.) and because the proposed action already has been determined not to jeopardize listed Snake River chinook salmon, those action-area requirements will be considered to be satisfied if mortality and sublethal effects on steelhead caused by operation of the FCRPS under the proposed action are less than or equal to those experienced by Snake River chinook.

In making this determination, NMFS must consider each element of the RPA to ensure that Snake River steelhead receive, at a minimum, the same protection afforded to Snake River spring/summer chinook salmon under the RPA. The RPA relies upon:

(1) <u>interim actions</u>, intended to provide for "implementation of all reasonable measures for the operation and configuration of the FCRPS that will reduce the mortalities of listed fish" (1995 Biological Opinion, p. 91) and studies to make the best choice regarding the long-term action; and

(2) <u>long-term actions</u> that include "major structural improvements to the FCRPS that result in significant survival improvements" (1995 FCRPS Biological Opinion, p. 128).

The 1995 FCRPS Biological Opinion recognized that the interim action alone would jeopardize Snake River salmon and that the long-term action was required for survival and recovery of the species. "Analyses conducted by NMFS...indicate that the reasonable and prudent actions will contribute to the survival of listed stocks and to their recovery <u>once major structural modifications are implemented</u>" (1995 FCRPS Biological Opinion p. 128, emphasis added). Until the best long-term action is chosen and implemented, the interim action "aggressively pursues improvements in survivals of both in-river migrants and transported fish" to keep the status of the listed species from further deteriorating prior to implementation of the long-term action. The conclusion that the RPA avoids jeopardy was based in part on the determination that "the action agencies are taking all reasonable measures with respect to the FCRPS to reduce listed salmon mortalities" (1995 FCRPS Biological Opinion, p. 129).

The suite of interim actions must be reviewed with respect to relative survival of Snake River steelhead compared to survival of Snake River spring/summer chinook salmon. Particular questions include:

(1) for each interim measure in the RPA, as written in the 1995 FCRPS Biological Opinion, does the seasonality and geographical extent of the measure provide the same reduction in FCRPS mortality to Snake River steelhead as to Snake River spring/summer chinook salmon;

(2) have the interim measures in the RPA been implemented according to the schedule and in the manner anticipated in the 1995 FCRPS Biological Opinion and, if not, are additional measures required to provide listed species with the reductions in FCRPS mortality assumed at the time the 1995 FCRPS Biological Opinion was issued;

(3) are there aspects of the Snake River steelhead life history that differ significantly from Snake River spring/summer chinook life history and therefore require protective measures, relative to FCRPS operation, that were not anticipated in the original RPA measures; and

(4) have <u>all</u> reasonable measures for the operation and configuration of the FCRPS to reduce mortalities of Snake River steelhead been included?

The suite of interim studies must also be reviewed to determine if the conclusions of those studies will provide adequate information for making a long-term configuration change that will benefit Snake River steelhead.

Regarding long-term actions, there are "two primary choices for major structural improvements at the lower Snake projects: surface collectors [with smolt transportation] and drawdowns" (1995 FCRPS Biological Opinion, p. 93). The adequacy of each pathway, with respect to Snake River steelhead, must be evaluated in a similar manner as evaluation of the interim measures in the RPA.

V.D.1.b. Upper Columbia River Steelhead

Because Upper Columbia River steelhead action-area biological requirements are assumed to be equivalent to Snake River chinook action-area biological requirements, a comparison is made among hydro-related effects on each species in Section VI, as was described for Snake River steelhead. Elements of the interim and long-term RPA must be reviewed with respect to the geographic distribution and life history of Upper Columbia River steelhead, employing the considerations described for Snake River steelhead in Section V.D.1.a.

V.D.1.c. Lower Columbia River Steelhead

Because Lower Columbia River steelhead action-area biological requirements are assumed to be equivalent to Snake River chinook action-area biological requirements, a comparison is made among hydro-related effects on each species in Section VI, as was described for Snake River steelhead. Elements of the interim and long-term RPA must be reviewed with respect to the geographic distribution and life history of Lower Columbia River steelhead, employing the considerations described for Snake River steelhead in Section V.D.1.a.

V.D.2. Effects of the Proposed Or Continuing Action In the Context of the Full Life Cycle to Determine If Species-Level Biological Requirements Are Likely To Be Met

V.D.2.a. Snake River Steelhead and Upper Columbia River Steelhead

The 1995 FCRPS Biological Opinion applied quantitative analytical techniques developed and implemented by a multi-agency technical group to assess whether operation of the FCRPS would satisfy species-level biological requirements. Development of the analytical methods (risk analysis framework) and tools (e.g., run reconstructions and simulation models) took several years. Analogous tools for comprehensive evaluation of species-level biological requirements are currently not available for Snake River steelhead.

A comprehensive modeling analysis of Snake River steelhead is currently planned by the multi-agency PATH group and an analysis of Upper Columbia steelhead may also be added. A preliminary version of this analysis will be available in late 1998 and a more complete analysis should be available in 1999.

Until the PATH analysis is available, a simpler technique must be employed for assessing the impact of proposed hydro actions (in combination with other actions) on the likelihood that Snake River steelhead and Upper Columbia River steelhead will survive and recover. This simpler analysis, which is being coordinated with PATH, provides an indication of the ability to meet species-level biological requirements defined in Section V.A.2.a and V.A.2.b when the proposed action is fully implemented.

Likelihood That Necessary SAR Will Be Met Under the Proposed Action The interim approach defines the incremental change in survival necessary for current Snake River steelhead SARs to reach historical target SAR levels, and compares that to the incremental change necessary for Snake River spring/summer chinook salmon to reach historical target SARs. Assumptions of this method are as follows:

The first assumption is that the smolt-to-adult return rates (SAR) of Snake River spring/summer chinook and Snake River steelhead during a historical period correspond to survival rates that represent acceptable probabilities of survival and recovery, as described in Section V.A.2. This assumption, that historical SAR rates can be used as a proxy for acceptable probabilities of survival and recovery, has been partially validated for Snake River spring/summer chinook salmon by PATH (Marmorek and Peters 1998 - DRAFT). However, this assumption has not been validated for steelhead.

A second assumption of this methodology is that, because the proposed action (including long-term measures, assumptions about survival changes in other parts of the life cycle, and assumptions about climate variability) has been determined not to jeopardize Snake River spring/summer chinook salmon (i.e., to result in acceptable probabilities of survival and recovery), the proposed action can be assumed to result in a survival change sufficient to bring recent Snake River spring/summer chinook SARs to the historical target SAR level.

The third assumption of this methodology is that the incremental change between current and target historical Snake River steelhead SAR levels is equal to or less than the incremental change necessary for Snake River spring/summer chinook salmon. This assumption is currently being evaluated by a subcommittee of PATH. If this third assumption is correct, then the proposed action is likely to result in achievement of historical target SARs for Snake River steelhead (i.e., not jeopardize steelhead) if the change in survival within the action area is the same or greater for steelhead, compared to chinook (as discussed in VIII.A.1). Conversely, if the incremental change between recent and historical steelhead SARs is greater than the incremental change needed by chinook, the proposed action will have to result in a greater increase in steelhead survival within the action area, compared to the increase in chinook survival.

[Preliminary results of the evaluation of the third assumption are described in Section VI.A.4. These results are subject to change.]

V.D.2.b Lower Columbia River Steelhead

It has not been possible to develop an interim method for evaluating the effect of the proposed action on species-level biological requirements of Lower Columbia River steelhead. This assessment will be based on qualitative considerations, as discussed in Section V.A.2.c.

V.E. Reasonable and Prudent Alternatives To a Proposed Or Continuing Action That is Likely To Jeopardize the Continued Existence of the Listed Species

This step is relevant only when the conclusion of the previously-described analysis is that the proposed action will jeopardize listed species. The reasonable and prudent alternative will have to reduce mortality associated with the proposed action to a level that does not jeopardize the species. An analysis to determine sufficiency of the reasonable and prudent alternative will be based on the same considerations described above.

VI. ANALYSIS OF EFFECTS

VI.A. Effects of Proposed FCRPS Operation by Action Agencies (Corps, BPA, BOR)

VI.A.1. Effect of Water Regulation and Impoundment of Mainstem Free-Flowing River Sections

VI.A.1.a Effects of Water Regulation and Impoundment With Respect to Biological Requirements Within the Action Area

The physical effects of water regulation and impoundment are well-known (e.g., NRC 1995, NMFS 1995 , and ISG 1996) and can be related to the biological requirements of steelhead in the migration corridor (Section V). Water regulation by the Action Agencies results in modification of the natural hydrograph and affects listed steelhead between upriver storage reservoirs and the ocean area influenced by Columbia River plume. Water regulation reduces flows (water quantity per unit time) that would naturally occur in the spring and this in turn reduces water velocity. Water velocity is further reduced by impoundment of mainstem river sections, which increases volume and cross sectional area, forming reservoirs from formerly free-flowing river sections. Snake River steelhead must pass through eight federal impoundments, Upper Columbia steelhead must pass through four (plus up to five additional non-federal impoundments), and Lower Columbia River steelhead must pass through one. Water regulation and impoundment also change water quality factors such as temperature (increased due to mass heat storage) and turbidity (decreased), as well as salmonid prey production (which changes from riverine aquatic insects to lacustrine planktonic organisms). Channel complexity is also reduced in reservoirs, which affects complexity of fluid dynamics (e.g., ISG 1996) and substrate.

Slower water velocity is associated with a reduction in juvenile steelhead migration speed (e.g., Berggren and Filardo 1993; Buettner and Brimmer 1995; Giorgi et al. 1997) and an increase in adult steelhead migration speed during active migration seasons (e.g., reviews in Bjornn and Peery 1992 and Chapman et al. 1994). Slower juvenile migration rate may result in arrival at the estuary at a time or under conditions in which the species did not evolve, which could influence survival. Impoundment has created low-velocity habitat for predators (e.g., Faler et al. 1988; Mesa and Olson 1993), increased water temperatures have increased predation rates (e.g., Vigg and Burley 1991), and slower fish migration speed (and concentration at dams - see Section V.A.3) has presumably increased exposure of juvenile steelhead to predation. The lack of natural complexity within the migration corridor and the shift in juvenile prey associated with lacustrine habitat may also affect juvenile steelhead survival (ISG 1996). These and other potential causal relationships (see ISG 1996, Fig. 6.1) suggest that juvenile steelhead survival is reduced by impoundments and low flows caused by federal water regulation. This conclusion is supported by Petrosky (1998 - DRAFT), who demonstrated an association between smolt-to-adult survival of Snake River steelhead and combined Snake and Columbia River flows (expressed as fish travel time from Lower Granite pool to Bonneville Dam).

VI.A.1.b. Reduction of Adverse Effects of Water Regulation and Impoundment Through Proposed Measures

VI.A.1.b.1) Reduction of Adverse Effects of Water Regulation and Impoundment Through Flow Augmentation

Interim Measures in RPA Flow augmentation is a special case of water regulation, in which the primary purpose of releases from storage reservoirs is to aid salmonid migration, rather than to generate power, provide flood control, or meet other project objectives. Interim period releases are timed to coincide with juvenile salmon and steelhead migration periods, as determined in-season by the Technical Management Team, without drafting storage reservoirs below levels that would likely reduce available water in subsequent years (RPA 1). For both Snake River steelhead and Lower Columbia River steelhead, the interim period flow augmentation designed to partially mitigate the effects of federal water regulation and impoundments is the spring Lower Granite and McNary flow targets and their implementation, as described in the 1995 FCRPS Biological Opinion’s RPA 1.

Long-Term Measures in RPA The long-term flow augmentation actions include identifying and providing additional volumes of water for flow augmentation from the upper Snake River (RPA 1.b) and Canada (RPA 1.d). Studies to determine the most effective use of available water are also required (e.g., flow “pulsing” evaluation [RPA 13.g], and various flow/survival studies [RPA 13.c and 13.f]).

Supplemental Proposed Action As described in Section III, the proposed action includes adoption of a mid-Columbia flow objective of 135 kcfs from April 10 to June 30 and various specific measures, including a shift in flood control timing, to increase the likelihood that the flow objective can be met. Details are included in **Appendix A**. The purpose of this supplemental proposed action is to provide Upper Columbia River steelhead with similar reductions in mortality associated with water regulation, as those afforded to Snake River spring/summer chinook salmon through the Lower Granite and McNary flow targets specified in the 1995 RPA.

VI.A.1.b.2) Reduction of Adverse Effect of Water Regulation and Impoundment By Lowering Reservoir Elevations

Interim Measures in RPA Because reducing the cross-sectional area of a reservoir is equivalent (from the standpoint of average water velocity) to increasing the flow, reduction of Snake River run-of-river reservoir elevations to within one foot of the minimum elevations authorized for each project (minimum operating pool; MOP) could partially mitigate the impacts of impoundment during interim operations (RPA 4). Additionally, the Action Agencies were directed to investigate reducing the elevation of John Day pool to within three feet of MOP during the juvenile migration period (RPA 5).

Long-Term Measures in RPA The Action Agencies were directed to complete necessary feasibility and design work to prepare for drawdown of Snake River reservoirs to spillway crest or natural river level, to begin by 2000 (RPA 10). Spillway crest drawdowns could potentially reduce adverse effects of water management and impoundment, while natural river drawdowns would additionally reduce adverse effects of migration barriers (see section VI.A.3).

Supplemental Proposed Action As described in Section III, the proposed action includes a feasibility study to determine the long-term action for lower Columbia River projects. This study will consider possible natural river drawdowns of John Day and/or McNary reservoirs. The principal purpose of this supplemental proposed action is to provide long-term measures for Upper Columbia steelhead that parallel those included in the 1995 RPA for Snake River spring/summer chinook salmon. Effects on listed Snake River populations will also be considered as will effects on other fish and wildlife species throughout the Columbia River basin.

VI.A.1.b.3) Reduction of Adverse Effect of Water Regulation and Impoundment By Predator Removal

Interim and Long-Term Measures in RPA Continued evaluation of predator removal to reduce reservoir predation was required by RPA 14 to partially mitigate the effect of impoundments in creating low-velocity predator habitat and the effect of dams in concentrating juvenile smolts, making them more susceptible to predation. Additionally, the Action Agencies were directed to study effects of bird predation and ways to reduce it (Incidental Take Statement term and condition number 9 [IT 9]).

VI.A.1.b.4) Reduction of Adverse Effect of Water Regulation and Impoundment By Temperature Regulation

Interim and Long-Term Measures in RPA IT17 called for monitoring river temperatures and implementing, when possible, temperature control measures in the lower Snake River such as releasing cool water from Dworshak Dam and the Hells Canyon complex. Measures were also required to alleviate warm temperatures in the McNary Dam juvenile fish facility (IT 5) and in adult fish ladders at various projects (IT 18).

VI.A.1.c. Relative Effect of Water Regulation and Impoundment, and Measures to Reduce Associated Mortality, on Listed Steelhead and Snake River Chinook Salmon

VI.A.1.c.1) Juveniles

Reservoir Survival The factors considered in Section VI.A.1 primarily affect reservoir survival of juveniles. Reservoir-specific estimates of survival are not available for either chinook salmon or steelhead. Reach survival estimates, which include effects of dams in addition to effects of water regulation and impounded reservoirs, are described in section VI.A.3. The efficacy of flow augmentation and lowered reservoir elevations can be evaluated by looking at the strength of the association between flow and migration speed or reach survival for each species.

Migration Speed Migration speed of steelhead at a given flow is generally greater in steelhead than in yearling chinook salmon, suggesting that exposure time to predation may be lower in steelhead and estuary arrival timing may be closer to that under which the species evolved (**Table 1**). Migration speed is positively correlated with flow for Snake River steelhead and Upper Columbia River steelhead, as reviewed in **Appendix A**. Information specific to Lower Columbia River steelhead is not available.

Flow vs Survival The efficacy of flow augmentation and/or lowering reservoir elevations (which reduces water velocity in a manner comparable to increasing flow) for reducing Snake River steelhead mortality is very similar to the efficacy of flow augmentation for reducing Snake River spring/summer chinook mortality. Smith et al. (1998) found that the regression of reach survival of primary release groups between Lower Granite Reservoir and Lower Monumental Dam in 1994 through 1995 on flow was highly significant for each species, with comparable predictive power (R^2=0.65 for yearling chinook and R^2=0.52 for steelhead). Slopes also were nearly identical (0.0040 for chinook and 0.0038 for steelhead), suggesting a similar association between flow and survival in the two species. Regressions of survival of daily release groups between Lower Granite Dam and Lower Monumental Dam in 1994 through 1996 on flow also were highly significant and very similar for the two species, although the predictive power of the regressions was poor.

Similar information regarding reach survival vs flow is not available for Upper Columbia River steelhead and Lower Columbia River steelhead. It is likely that Upper Columbia River steelhead reach survival is affected by flow regulation in a similar manner to Snake River steelhead. However, applicability of this information to Lower Columbia River steelhead, which pass no more than one dam during emigration, is unknown.

Table 1. Comparison of migration speed of yearling chinook and steelhead in the Snake and Columbia Rivers, from bivariate flow:travel time relationships. Flows of 85 to 100 kcfs are examined because these correspond to the spring Snake River flow targets to which Snake River chinook are exposed. Closest flows to 85 to 100 are examined in the mid-Columbia to indicate similar flows for Upper Columbia steelhead. Studies in Bonneville pool that would be relevant to Lower Columbia steelhead are not available.

Flow and Location	**Migration Speed of Yearling Chinook**	**Migration Speed of Steelhead**	**Study**
85-100 kcfs Lower Granite Dam to McNary Dam	11.6-12.7 mi/day (hatchery)	13.6-16.2 mi/day (hatchery)	Berggren and Filardo (1993)
85-100 kcfs Lower Granite Dam to Lower Monumental Dam	7.2-7.6 mi/day (hatchery)	7.4-9.2 mi/day (hatchery)	Smith et al. (1998) - SH range includes annual variability 1994-96
85-100; 110-130 kcfs Rock Island Dam to McNary Dam	11.0-11.8 mi/day at 85-100; 12.3-13.2 mi/day at 110-130 (Mixed)	14.2-16.0 mi/day at 85-100; 17.2-19.6 mi/day at 110-130 (Wild)	Giorgi et al. (1997)
85-100; 110-130 kcfs Methow River to McNary Dam	9.0-9.1 mi/day at 85-100; 9.1 mi/day at 110-130 (Hatchery)	12.0-13.8 mi/day at 85-100; 13.7-14.8 mi/day at 110-130 (Hatchery)	Berggren and Filardo (1993)

Average flow during the outmigration can also be compared to smolt-to-adult returns to evaluate the effect of flow on survival. Caveats regarding application of this approach to determining effects of the FCRPS on survival are explained in **Appendix A**. A significant relationship between SAR and average flow during juvenile Snake River spring/summer chinook salmon emigration was reviewed in NMFS (1995b). Similarly, Petrosky (1998-DRAFT) reported a significant ($P<0.001$; $r^2=0.37$) negative relationship between Lewiston to Bonneville fish travel time, which is a function of flow, and 1964 through 1993 estimates of wild Snake River steelhead SARs. **Appendix A** summarizes three time series of estimated SARs of wild and hatchery Upper Columbia River steelhead (in some cases, mixed with Middle Columbia River steelhead) and compares them with average flow conditions during smolt migration. In each case, SARs were generally higher when mean flows were higher and SARs were lower when mean flows were lower, although a statistically significant relationship could be detected for only one data set. Similar flow vs SAR relationships are not available for Lower Columbia River steelhead.

<u>Migration Timing in Relation to Flow Augmentation and Reservoir Drawdowns</u> Timing of the Snake River steelhead juvenile migration is similar to that of Snake River spring/summer chinook. Therefore, the timing of flow objectives for Snake River spring/summer chinook salmon, as

described in 1995 RPA 1, should be sufficient to provide comparable benefits for Snake River steelhead.

Appendix A cites a variety of observations suggesting that April 10 through June 30 are reasonable planning dates for flow objectives for Upper Columbia River steelhead. The supplemental proposed action adopts these planning dates in defining mid-Columbia flow objectives.

Because Lower Columbia River steelhead migrate through at most one reservoir and dam, flow objectives have not been specifically defined for this species, nor have planning dates for flow augmentation. Limited available information suggests that the McNary flow objectives and planning dates described in 1995 RPA 1 should be sufficient for the lower Columbia River steelhead ESU.

<u>Predation</u> Limited information on predation rates in John Day reservoir suggests that predators such as squawfish and smallmouth bass cause a higher mortality rate for juvenile steelhead (mixture of Snake River, Upper Columbia River, and Middle Columbia River steelhead) than for juvenile yearling chinook (**Table 2**). If the observations in John Day Reservoir are applicable to other reservoirs, removal of a given number of squawfish should reduce the steelhead predation rate more than the yearling chinook predation rate. (For example, **Table 2** suggests that if half of the predators could be removed in April, steelhead mortality in John Day reservoir for that month would presumably be reduced 6 percent while yearling chinook mortality would be reduced 4 percent).

Table 2. Estimated mortality of juvenile salmon and steelhead from predation by month in John Day reservoir, 1983 through 1986. Predators considered were northern squawfish (<u>Ptychocheilus</u> <u>oregonensis</u>), walleye (<u>Stizostedion</u> <u>vitreum</u>), and smallmouth bass (<u>Micropterus</u> <u>dolomieu</u>). During April and May virtually all chinook salmon are yearling chinook salmon, based on McNary Dam smolt monitoring. During July, chinook salmon are a mixture of yearlings and subyearlings, so this the reported mortality rate is greater than the yearling chinook mortality rate. (From Table 6 of Reiman et al. 1991).

Month	**Steelhead**		**Chinook Salmon**	
	Mortality Rate	**Standard Deviation**	**Mortality Rate**	**Standard Deviation**
April	0.12	0.061	0.08	0.034
May	0.11	0.031	0.11	0.017
June	0.13	0.089	0.07	0.025

VI.A.1.c.2) Adults

Temperature Control Technical Management Team decisions through 1995 RPA 1.g. and water conditions during the past four years have resulted in water temperatures that have not exceeded 70° F during the late summer, as measured at Ice Harbor Dam (BA section 4.3.2.1). Although the peak of the adult Snake River steelhead migration is generally earlier than the peak of the Snake River fall chinook, which may lead to exposure of a larger proportion of the steelhead to higher temperatures, it is likely that both species are similarly affected by late summer water management. Upper Columbia River steelhead and Lower Columbia River steelhead do not appear to be exposed to the same high temperatures that occur in the Snake River.

VI.A.2. Barriers to Migration

VI.A.2.a Effects of Barriers to Migration With Respect to Biological Requirements Within the Action Area

Presence of dams results in some migrational delay, thereby influencing migration speed and timing of both adults and juveniles. Additionally, dams impede safe passage of juveniles and, to a lesser extent, adults. Some juvenile mortality is associated with all routes of passage at dams, with highest mortality occurring through turbines (e.g., reviewed in Whitney et al. 1997). Some passage routes have additional effects, such as the increase in total dissolved gas (water quality) caused by high spill levels.

For Snake River steelhead, operation of the eight Snake and Lower Columbia river dams is included in the proposed action. For Upper Columbia River steelhead, operation of the four lower Columbia River dams is included in the proposed action. For Lower Columbia steelhead, only Bonneville Dam operation is included.

VI.A.2.b. Reduction of Adverse Effects of Barriers to Migration Through Proposed Measures

VI.A.2.b.1) Reduction of Adverse Effects of Barriers to Migration Through Spill

Interim Measures in RPA Because mortality associated with juvenile passage via the spillway is very low (e.g., 0 to 2 percent, based on review of 13 studies by Whitney et al. 1997), minimum spill levels were established at all projects to reduce the proportion of smolts passing through turbines(RPA 2). To allow higher spill levels without causing detrimental effects of high total dissolved gas (TDG) levels, gas abatement studies and implementation of specific measures such as spill deflectors at Ice Harbor and John Day were required (RPA 18). Additionally, physical and biological monitoring of TDG effects was required (RPA 16).

<u>Long-Term Measures in RPA</u> Studies to examine methods of more effectively attracting surface-oriented juveniles to the spillway were required (RPA 11), with the intention of implementing new designs in the future if tests are successful. In addition to specifying interim period gas abatement measures such as spill deflectors, RPA 18 also required studies to identify long-term gas abatement measures such as tailrace modifications.

<u>Supplemental Proposed Action</u> As described in Section III, the proposed action includes spill additional to that required by 1995 RPA 2 at some projects in order to improve survival for in-river migrants. Details are included in **Appendix C**.

VI.A.2.b.2) Reduction of Adverse Effect of Barriers to Migration Through Juvenile Bypasses

<u>Interim Measures in RPA</u> Juvenile bypasses divert a proportion of the juveniles approaching turbine intakes into channels that route fish into holding areas for transportation or else route fish back to the river downstream of the dam. A number of elements of the reasonable and prudent alternative were implemented in an attempt to make this mitigation feature more effective. Some specific measures include: install extended-length screens at three projects to improve guidance into the bypasses (RPA 19 and 21) and relocate bypass outfalls at Bonneville Dam (RPA 23 - second powerhouse outfall will be completed by 1999 but first powerhouse outfall will not [BA section 4.7.11]). Several other interim measures called for in the RPA have been deferred until after 1999.

<u>Long-Term Measures in RPA</u> Long-term measures include: investigate methods of bypassing surface-oriented juveniles, before they dive and approach turbine intakes (RPA 11); improve guidance at Bonneville Dam above current levels (RPA 12); conduct studies to improve existing bypasses such that at least 80 percent of juveniles pass via non-turbine routes and have at least 95 percent survival (RPA 15); improve the bypass and associated fish facility at Lower Granite Dam (RPA 20 - although this action was originally specified as interim, it has now been deferred until after 1999 [BA section 4.7.8]); and design a juvenile bypass system for The Dalles Dam (RPA 24 - completion by 1999 is dependent upon results of prototype surface bypass/collector tests in 1998 [BA section 4.7.12]).

VI.A.2b.3). Reduction of Adverse Effect of Barriers to Migration Through Turbine Operations

Interim Measures Passage through turbines is the route that causes highest juvenile mortality (e.g., review in Whitney et al. 1997; Muir et al 1997) as well as adult fallback mortality (Wagner and Ingram 1973), so most measures to partially mitigate effects of dams attempt to pass juveniles through other routes, as described above. One method of reducing the mortality of those juveniles that do pass through turbines is to operate turbines near peak efficiency. RPA 6 requires that this occur during the salmon passage season.

VI.A.2.b.4) Reduction of Adverse Effect of Barriers to Migration Through Adult Fishways and Extended Operation of Juvenile Bypasses to Reduce Adult Fallback

Interim Measures Ladders designed to reduce delay and facilitate adult passage are in place at all dams. Measures to improve the effectiveness of adult fishways include maintaining ladders in criteria for optimal fish passage during the passage season (RPA 7) and maintaining spare parts and back-up systems sufficient to ensure their proper operation (IT15 and IT16). Additionally, juvenile fish facilities are operated longer than necessary for juveniles, in order to protect adults from falling back at a project through turbines (RPA 8).

VI.A.2.c. Comparison of Effects for Listed Steelhead and Snake River Chinook Salmon

VI.A.2.c.1) Juveniles of All Species

Turbine Survival Turbine survival studies published through 1990 at Snake and lower Columbia River dams have been reviewed by Iwamoto and Williams (1993). The Independent Scientific Group (ISG 1996) and Whitney et al. (1997) reviewed studies published through 1995, including several from mid-Columbia projects. At least one other turbine survival study has been conducted since that time (Normandeau Associates and Skalski 1997).

Turbine mortality has been estimated primarily for juvenile salmon, although at least two studies have estimated steelhead mortality (Weitkamp et al. 1980; Olson and Kaczynski 1980). Estimates of turbine mortality vary greatly among studies, ranging from 2.3 percent to 19 percent. Whitney et al. (1997) pointed out that studies that recovered marked fish in the tailrace very quickly using radio-tags resulted in estimates of 7 percent mortality or less (average 5.5 percent). Results of Normandeau Associates and Skalski (1997), not reviewed by Whitney et al. (1997), also fit into this category. Other studies with longer times between turbine passage and recovery averaged 10.9 percent mortality. Whitney et al. (1997) suggested that the lower estimates most likely estimate mortality directly associated with turbine passage while the others probably include factors beyond the turbine, such as predation of disoriented smolts.

With only two steelhead turbine mortality estimates among the more than 20 salmon estimates, it is not possible to determine if there is a difference in survival among species. The range of estimates in the steelhead studies (3 to 16 percent) is similar to the range in chinook studies (2.3 to 19 percent), but may be more closely related to the type of turbines involved. The steelhead estimate for Kaplan turbines and a "long" recovery period technique was 16 percent, which is similar to the majority of "long" recovery chinook studies, which mainly involved Kaplan turbines. The steelhead estimate for bulb turbines was 3 percent, which can be compared directly to a 7 percent mortality for coho salmon estimated in the same study.

In summary, it is unlikely that turbine survival of steelhead is different from turbine survival of yearling chinook salmon. The RPA measures to either (1) route juvenile migrants to bypasses or spillways or (2) reduce turbine impacts by operating them at peak efficiency are unlikely to affect steelhead differently than chinook, although this cannot be documented with available information.

Spill Survival Whitney et al. (1997) reviewed 13 estimates of spill mortality (3 steelhead and 10 salmon) published through 1995 and concluded that 0 to 2 percent is the most likely range for standard spill bays. However, they also pointed out that local conditions such as back eddies or other situations that may favor the presence of predators may lead to higher spill mortality. In some studies reviewed by Whitney et al (1997), point estimates for mortality in spill bays with spill deflectors were higher than estimates for spill bays without deflectors, but there were no statistical differences between the two. This also occurred in two more recent studies (Muir et al. 1997; Dawley et al. 1997), but there were significant differences between the two spillway types in another recent study (Normandeau et al. 1996) and a fourth study showed statistically significant differences at one flow rate but not at others (Mathur et al. 1997).

In general, steelhead spill survival estimates are the same as salmon spill survival estimates, since two of three available estimates are 0 to 2.2 percent. One exception is an estimate of 27.5 percent steelhead mortality associated with passage through a spill bay without a deflector at Lower Monumental Dam (Long et al. 1975). In the same study, the authors found a more normal spill mortality rate (2.2 percent) associated with a spillbay equipped with a deflector. The authors recognized that the "without-deflector" result was highly unusual and proposed that a condition favoring predation below the test spillway may have affected results.

Bypass Survival Direct bypass survival is defined as survival past systems including turbine intake screens, gatewells, orifices, bypass flumes, and, in some cases, dewatering screens, wet separators, sampling facilities including holding tanks, and bypass outfall conduits. Indirect

Table 3. Percent facility mortality at juvenile fish facilities, 1993 to 1996, from Martinson et al. (1997) and Spurgeon et al. (1997).

Dam and Year	Yearling Chinook (Mixed)	Yearling Chinook (Wild)	Steelhead (Wild)	Difference (SH - CH)
Lower Granite				
1993		0.003	<0.001	-0.002
1994		0.004	<0.001	-0.003
1995		0.002	<0.001	-0.001
1996		0.009	<0.001	-0.008
Little Goose				
1993		0.004	0.001	-0.003
1994		0.012	0.002	-0.010
1995		0.006	0.001	-0.005
1996		0.012	0.002	-0.010
Lower Monumental				
1993		0.001	0.001	0.000
1994		0.005	0.003	-0.002
1995		0.002	0.001	-0.001
1996		0.004	0.001	-0.003
Ice Harbor				
1996		0.000	0.000	0.000
McNary				
1993	0.006		0.002	-0.004
1994	0.011		0.005	-0.006
1995	0.001		<0.001	0.000
1996	0.001		0.001	0.000
Bonneville PH1				
1993	0.001		0.000	-0.001
1994	0.002		0.001	-0.001
1995	0.001		0.000	-0.001
1996	0.002		0.001	-0.001
Bonneville PH2				
1993	0.007		0.000	-0.007
1994	0.013		0.004	-0.009
1995	0.006		0.015	0.009
1996	0.005		0.005	0.000

bypass mortality may be associated with predation that occurs at a poorly-sited bypass outfall or delayed mortality caused by bypass passage, but expressed further downstream. A minimum estimate of mortality can be determined from observations of dead fish in sampling facilities. **Table 3** summarizes recent yearling chinook and wild steelhead facility mortality estimates at juvenile sampling facilities in recent years. These estimates suggest that direct bypass mortality of both wild steelhead and yearling chinook is generally less than 1 percent and that in nearly all cases juvenile steelhead facility mortality is less than yearling chinook mortality.

No measure of indirect mortality (following outfall release) is available at most projects for juvenile steelhead. However, studies of subyearling chinook bypass mortality at Bonneville 1 and 2 powerhouse (Ledgerwood et al. 1990, 1994; Dawley et al. 1996) indicate that high bypass mortality may be associated with predation that occurs at a poorly-sited bypass outfall or delayed mortality caused by bypass passage, but expressed further downstream. A minimum estimate of mortality can be determined from observations of dead fish in sampling facilities. **Table 3** summarizes recent yearling chinook and wild steelhead facility mortality estimates at juvenile sampling facilities in recent years. These estimates suggest that direct bypass mortality of both wild steelhead and yearling chinook is generally less than 1 percent and that in nearly all cases juvenile steelhead facility mortality is less than yearling chinook mortality.
predation may be associated with bypass outfalls at that project. There is no information to suggest that indirect mortality is higher for steelhead than for yearling chinook salmon at any projects under current conditions.

<u>Fish Guidance Efficiency</u>

The effectiveness of intake screens in diverting fish approaching the turbines into bypass systems is known as fish guidance efficiency. FGE differs among wild and hatchery yearling chinook salmon (Krasnow 1998 - DRAFT) but appears to be identical for wild and hatchery steelhead (S. Smith, NMFS, pers. comm. 1998), based on analysis of recent PIT-tag detection rates. For both species, there is uncertainty regarding the change in FGE occurring since the replacement of standard length travelling screens (STS) with extended-length bar screens (ESBS) at several projects (Krasnow 1998 - DRAFT; Marmorek and Peters 1998 - DRAFT). Side-by-side estimates of STS vs ESBS FGE using fyke-net recoveries indicate that FGE is considerably higher with ESBS than with STS (e.g., McComas et al. 1993; Gessel et al. 1994; Brege et al. 1994). However, this difference has not been confirmed under full operating conditions, based on PIT-tag detection rates before and after ESBS installation at Snake River projects (IDFG analysis reported in Krasnow 1998 - DRAFT). PATH has recommended examining sensitivity to both assumptions.

Table 4 indicates that relative guidance of steelhead and yearling chinook salmon varies by project, chinook origin, and ESBS vs STS assumption. Steelhead FGE is estimated to be

Table 4. Estimates of fish guidance efficiency (FGE) with current project configurations, from Krasnow (1998 - DRAFT) and S. Smith (NMFS, pers. comm. 1998). Estimates are made for two assumptions about the effectiveness of extended-length bar screens (ESBS), relative to standard travelling screens (STS). Position of operating gate affects FGE, as described in Krasnow (1998 - DRAFT). ROG = raised operating gate; SOG = stored operating gate; LSTS = lowered standard travelling screen; STR = streamlined trash rack; TIE = turbine intake extension.

Dam	Current Fish Guidance Configuration/Structure	ESBS>STS				ESBS=STS				Difference (SH - Wild CH)
		Yearling Chinook			Steelhead	Yearling Chinook			Steelhead	
		Wild	Hatchery	Mixed		Wild	Hatchery	Mixed		
Lower Granite	6 of 6 turbines w/ ESBS, ROG	0.78	0.73	0.75	**[0.84]**	0.55	0.46	0.47	**[0.84]**	**[0.06 to 0.29]**
Little Goose	6 of 6 turbines w/ ESBS, ROG	0.82	0.76	0.78	--	0.64	0.52	0.54	--	
Lower Monumental	6 of 6 turbines w/ STS, SOG	0.61	0.47	0.49	--	0.61	0.47	0.49	--	
Ice Harbor	6 of 6 turbines w/ STS, ROG	0.71	0.60	0.62	0.74	0.71	0.60	0.62	0.74	0.03
McNary	14 of 14 turbines w/ ESBS, ROG	0.95	0.81	0.83	0.89	0.79	0.68	0.69	0.67	-0.06 to -0.12
John Day	16 of 16 turbines w/ STS, no OG	0.64	0.54	0.55	0.68	0.64	0.54	0.55	0.68	0.04
The Dalles	Ice and trash sluiceway w/ forebay overflow	0.46	0.39	0.40	0.40	0.46	0.39	0.40	0.40	-0.06
Bonneville I	10 of 10 units w/ STS, SOG	0.38	0.32	0.33	0.51	0.38	0.32	0.33	0.51	0.13
Bonneville II	8 of 8 units w/ LSTS, STR, alt TIE, SOG	0.44	0.37	0.38	0.39	0.44	0.37	0.38	0.39	-0.05

3 to 29 percent higher than yearling chinook FGE at all projects except McNary, The Dalles (which does not have a screened bypass system), and the Bonneville second powerhouse.

Spill Efficiency/Effectiveness

Spill effectiveness is the proportion of fish approaching a project that pass via the spillway, and spill efficiency is spill effectiveness divided by the proportion of total river flow that is passing over the spillway at the same time. Recent reviews of spill efficiency and effectiveness include Steig (1994), Giorgi (1996), Whitney et al. (1997), and Marmorek and Peters (1998 - DRAFT). Estimates of spill efficiency vary by project and, in some cases, can be described as functions of the proportion of project flow passing over the spillway. Nearly all spill efficiency studies are based on hydroacoustics, and they are therefore insufficient for distinguishing among steelhead and yearling chinook efficiency. One recent radio-telemetry study included relatively large numbers of each species and allows seasonal average comparisons of the proportion of fish that passed the dam by a known route that went through the spillway (Adams et al. 1997; their Figure 4-12). In this study, 37 percent of hatchery yearling chinook, 50 percent of hatchery steelhead, and 47 percent of wild steelhead over the course of the study period. Although the release timing distribution of the two species was not identical, so that the two species may not have been exposed to an identical distribution of spill conditions, these results suggest that the seasonal effectiveness of spill in passing steelhead was at least as great as that for yearling chinook in 1996 at Lower Granite Dam.

General - Timing and Applicability of Juvenile Chinook Measures for Juvenile Steelhead

Review of Smolt Monitoring Program index data for wild Snake River steelhead arriving at Lower Granite Dam has shown that, for the period 1985 through 1997, the mean date of arrival for at least 100 fish per day is April 3 (1993 was omitted because sampling did not begin until April 15 when an index of 1040 fish occurred). In some years wild steelhead arrive earlier than April 3 in substantial numbers (over 2000 fish per day 3/30/97); the migration generally commences the last week of March. Because of this discrepancy in timing, the supplemental proposed action for sets a planning date for initiating spill of April 3, rather than the April 10 date in 1995 RPA 2. In general, other planning dates for juvenile chinook appear to be adequate for juvenile steelhead. The end of season dates for spill, peak efficiency and bypass operations are designed to protect subyearling chinook and extend well past the end of the steelhead outmigration. Any unusual migration timing will be evident during in-season monitoring and protective measure start dates can be adjusted accordingly by the Technical Management Team.

VI.A.2.c.2) Adults of All Species

Adult Fallback Rates and Fallback Mortality (Chinook vs Steelhead)

[This section not complete - Table 5 = fallback rates at various projects/years for each species]

Adult Project Passage Delay (Chinook vs SH)

[This section not complete - Table 6 = 1st to last detection times per project by species]

Adult Passage Mortality Cumulative passage mortality for adult steelhead migrating up the Columbia and Snake Rivers through eight mainstem dams can be substantial. One estimate of loss is calculated from the difference in adult counts between successive dams (after adjustment for legal harvest) and represents loss and mortality. Mortality can be caused by:

- effects of delayed migration,
- fallback through turbines,
- illegal harvest,
- delayed mortality from marine mammal predation,
- gas supersaturation,
- gillnet interactions, and
- disease.

Apparent adult loss between dams may also be due to factors other than mortality of adults, such as:

- counting errors,
- double-counting fish that fall back and re-ascend ladders,
- straying, and
- tributary turnoff.

The combination of these effects has led to apparent adult passage losses between Bonneville Dam and Lower Granite Dam.

Another indication of adult passage loss (which excludes counting errors, double-counting fish that ascend ladders more than once, and straying or tributary turnoff) is data from radio tagging studies (Bjornn et al. 1992, 1994, 1995; Turner et al. 1984; Liscom et al. 1978; Ross 1983; Monan 1976). Based on these studies that compared passage of both chinook and steelhead, combined passage loss of radio-tagged fish in the lower Snake and lower Columbia Rivers, which is applicable to Snake River steelhead, is estimated to be 20.8 percent (79.2 percent survival) (Table 7; Ross 1998). The NMFS considers the 20.8 percent loss of radio-tagged Snake River steelhead to be more representative estimate of mortality attributable to passage through the FCRPS than estimates based on dam counts. This estimate of steelhead survival (79.2 percent) is greater than the 74.8 percent survival of chinook salmon, estimated in an identical manner using information from the same studies.

The survival of adult Upper Columbia River steelhead cannot be estimated through the upper dam in the same manner because of a lack of radio-telemetry studies in the mid-Columbia River. However, survival of Upper Columbia steelhead from Bonneville Dam to McNary Dam, which constitutes most of the impounded federal reach, can be determined in the same manner as described above, using a subset of the observations. Steelhead survival from Bonneville to McNary averages 95.2 percent in these studies , compared to 88.4 percent survival of chinook salmon (Table 7; Ross 1998).

The survival of adult Lower Columbia River steelhead for those stocks of the ESU that spawn above Bonneville Dam can be inferred from estimates of survival past Bonneville Dam (Table 7; Ross 1998). Mean steelhead survival in these studies averages 96.4 percent, compared to 94.3 percent survival of chinook salmon.

General - Timing and Applicability of Adult Chinook Measures for Adult Steelhead

In general, the proposed action provides comparable measures for protection of adult steelhead as those contained in the RPA for protection of adult chinook. Although steelhead are present in the Snake and lower Columbia Rivers during the winter, limited monitoring during this period suggests that movement stops when temperatures fall to 4 to 5°C (reviewed in Bjornn and Peery 1992). During winter maintenance periods, one adult fishway remains operational at all times at federal projects with two fish ladders. At Lower Granite and Little Goose Dams, which have only one adult fishway, ladders are inoperable for only short periods during winter maintenance.

Table 7. Estimates of adult survival past Snake and Columbia River projects from radio-telemetry studies, as summarized in Ross (1998).

Project	Reference	Chinook Project Survival	Average Chinook Reach Survival	Steelhead Project Survival	Average Steelhead Reach Survival	Difference (SH - CH)
Bonneville	Turner et al. (1984)	0.900 (Fall)		0.943 (Fall)		0.043
Bonneville	Liscom et al. (1978)	1.000 (Spring)		0.925 (Summer)		-0.075
Bonneville	Ross (1983)	0.872 (Spring)		0.952 (Summer)		0.080
Bonneville	Ross (1983)	0.943 (Fall)		1.000 (Fall)		0.057
Bonneville	Monan (1976)	1.000 (Spring)		1.000 (Fall)		
Bonneville Mean			**0.943**		**0.964**	**0.021**
The Dalles	Liscom (1978)	0.985 (Spring)		1.000 (Summer)		0.015
The Dalles	Monan (1976)	0.946 (Spring)		1.000 (Summer)		0.054
The Dalles Mean			**0.966**		**1.000**	**0.034**
John Day	Liscom (1978)	1.000 (Spring)		1.000 (Summer)		0.000
Bonneville - McNary Estimate	**Ross (1998)**		**0.970**		**0.988**	**0.018**
Four Snake River Projects	Bjornn et al. (1992)	0.870		0.813		-0.057
Four Snake River Projects	Bjornn et al. (1994)	0.810		0.870		0.060
Four Snake River Projects	Bjornn et al. (1995)	0.861		0.813		-0.048

Table 7. Estimates of adult survival past Snake and Columbia River projects from radio-telemetry studies, as summarized in Ross (1998).

Project	Reference	Chinook Project Survival	Average Chinook Reach Survival	Steelhead Project Survival	Average Steelhead Reach Survival	Difference (SH - CH)
Four Snake River Projects Mean			**0.847**		**0.832**	**-0.015**
Estimate for Eight-Dam System	**Ross (1998)**		**0.748**		**0.792**	**0.044**

VI.A.3.a. Combined Effects of Water Regulation, Impoundment, and Barriers to Migration With Respect to Biological Requirements Within the Action Area

The effects previously described in sections VI.A.1 and VI.A.2 describe the impact of the proposed actions on action-area biological requirements. Additional impacts resulting from the combined effects of water regulation, impoundment, and barriers to migration are not apparent.

VI.A.3.b. Reduction of Adverse Combined Effects of Water Regulation, Impoundment, and Barriers to Migration Through Proposed Measures

VI.A.3.b.1) Reduction of Adverse Combined Effects of Water Regulation, Impoundment, and Barriers to Migration Through Transportation of Juveniles

Most studies indicate that transported juvenile steelhead return at a higher rate than in-river control fish similarly collected and marked, but allowed to continue their migration in-river under the current hydroelectric system configuration (reviewed in **Appendix B**). However, there is continuing controversy regarding the application of these results to mitigation measures affecting in-river fish runs, which are not collected and handled in the same manner as the experimental controls. Additionally, concerns regarding the lack of information on population-specific effects of transportation, relative to in-river migration under current conditions, prompted the Independent Scientific Advisory Board (ISAB 1998) to recommend a "spread-the-risk" policy in 1998, in which the majority of migrants of any salmon or steelhead stock would not be transported.

<u>Interim Action in RPA</u> RPA 3 required transportation around reservoirs and dams of most chinook and sockeye salmon, to avoid mortality associated with impoundment and dam passage. The Technical Management Team (TMT) has flexibility to reduce the percentage of juveniles transported from a given project (e.g., by increasing spill) in order to facilitate transport experiments in which it is desirable to provide best possible in-river conditions for non-transported mark groups or for other in-season considerations. RPA 3 concluded that, for McNary Dam, "there is sufficient uncertainty regarding benefits of transported yearling salmon to warrant suspending transport from that site during the spring." RPA 9 specified that barge exits should be enlarged to facilitate passage of transported juveniles from barges and RPA 25 specified that new barges should be constructed to reduce holding time of juveniles prior to barging. IT 8 required a study of short-haul barging operations.

<u>Supplemental Proposed Action</u> As described in Section III, the proposed action includes various measures to adopt the ISG's (1998) recommendation to "spread-the-risk" among transportation and in-river migration for listed stocks and to reduce the proportion of fish transported by truck.

Transportation from Snake River projects would be as described in the 1995 RPA, with the exception of a modification in 1995 RPA 2 that would change the Lower Granite spill trigger from 100 kcfs to 85 kcfs, as originally proposed by NMFS in **Appendix B**. Rationale for this change is described in that appendix. The effect of this change on transportation is a reduction in the proportion of fish approaching Lower Granite Dam that will be transported from that project in years in which the seasonal spring average flow is between 85 to 99 kcfs. 1995 RPA 3 would be modified to allow an experiment involving transportation from McNary Dam in 1999 or possibly future years. The immediate purpose of the experiment would be to evaluate the apparent high mortality of transported yearling chinook salmon from this project as determined from PIT-tag detections, with the intention of identifying means by which the problem can be corrected. The ultimate purpose of the experiment will be to allow future transportation of Upper Columbia River steelhead from McNary Dam in order to spread the risk among transportation and in-river migration for this ESU. Additional details are included in **Appendix B**.

<u>Long-Term Action in RPA</u> Some of the elements described in the interim action also continue as long-term actions (e.g., construction of new barges). Additionally, maximum transportation is considered one of the two major pathways for system operation following 1999. Model analyses in the 1995 FCRPS biological opinion indicated that under assumptions of a weak flow:survival relationship and high post-Bonneville survival of transported fish, survival and recovery of listed Snake River chinook stocks is possible by maximizing transportation. Several of the elements associated with long-term bypass improvements (VI.A.2.b.2), including development of surface bypass/collectors to improve collection of fish for transportation at some projects and improve in-river survival of non-collected fish at others, also support the long-term transportation option.

VI.A.3.b.2) Reduction of Adverse Combined Effects of Water Regulation, Impoundment, and Barriers to Migration Through Natural River Drawdown

Breaching dams and lowering reservoirs to natural (pre-impoundment) river levels has the potential to reduce adverse effects at the specific projects that are breached. Some level of mortality, above pre-impoundment natural mortality, may still be associated with natural river drawdowns because some period of time may be required for sediment to be flushed, natural channel conditions to stabilize, and predator populations to adjust to new habitat conditions. There may also be additional adverse effects associated with removing collector projects, since juveniles previously placed on barges would now have to migrate through four lower river dams and reservoirs that are currently avoided by transported fish.

<u>Long-Term Action in RPA</u> 1995 RPA 10 requires that the COE complete necessary feasibility, design and engineering work to allow drawdown of Snake River reservoirs to begin by 2000. Modeling analyses described in the 1995 FCRPS biological opinion concluded that under assumptions of a strong flow:survival relationship and poor survival of transported fish below

Bonneville Dam, drawdown of four Snake River reservoirs was necessary to ensure survival and recovery of listed Snake River salmon.

Supplemental Proposed Action As described in Section III, the proposed action includes a feasibility study to determine long-term configuration of the lower Columbia River reach. This feasibility study will include consideration of John Day and McNary drawdown, full-flow bypass at some projects, as well as other measures already anticipated in the 1995 RPA.

VI.A.3.c. Relative Combined Effects of Water Regulation, Impoundment, and Barriers to Migration and Measures to Reduce Associated Mortality, on Listed Steelhead and Snake River Salmon

VI.A.3.c.1) Juveniles

VI.A.3.c.1)a) Juvenile Snake River Steelhead

In-River Survival Under Interim Operations Recent PIT-tag studies of the survival through various reaches (combinations of dams and reservoirs) of the Snake River and to McNary Dam suggest that wild Snake River spring/summer chinook salmon survive at higher rates (approximately 1.2 to 6.5 percent higher survival per project) than wild Snake River steelhead (Smith et al. 1998 and Schiewe 1997b; **Table 8**). Results of studies involving hatchery fish or mixed hatchery and wild fish are variable, with Snake River steelhead surviving at higher rates than Snake River spring/summer chinook in some cases and at lower rates in others. Estimates of Snake River steelhead and chinook survival through lower Columbia River projects below McNary Dam under recent conditions are not currently available.

If it is assumed that: (1) the wild Snake River steelhead and Snake River spring/summer chinook mean per-project survivals in **Table 8** can be extrapolated to downstream projects; and (2) survival of in-river migrants under the interim operation (which transports all fish bypassed at three Snake river collector projects, leaving in-river fish to pass only through turbines or spill at those projects) is approximately 80 percent of in-river survival without transportation (pers. comm., P. Wilson, CBFWA [FLUSH model], and J. Hayes, Univ. of Washington [CRiSP model], 1998); then the range of in-river survival differences between Snake River steelhead and Snake River spring/summer chinook through eight projects is approximately 3 to 8 percent ($0.8*[0.988^8-0.983^8]$ to $0.8*[0.945^8-0.924^8]$).

Table 8. Seasonal average estimates of survival of yearling chinook and steelhead released in the Snake River, ascertained from PIT-tagging 1994-1996. A "project" refers to a dam + reservoir combination and a "reach" refers to river segment composed of one or more projects. Estimates in normal typeface are those reported in cited research. **Bold estimates are calculated in this table as: Mean Per-Project Survival = (Reach Survival)$^{-(\text{Number of Projects})}$; Approximate Eight-Project Survival = (Mean Per-Project Survival)^{8}.**

Study	Reach	Number of Projects	Steelhead Reach Survival (and **Mean Per-Project Survival**)	**Approximate Eight-Project Steelhead Survival**	Yearling Chinook Reach Survival (and **Mean Per-Project Survival**)	**Approximate Eight-Project Yearling Chinook Survival**	**Difference in Per-Project (and Eight-Project) Survival [SH - CH]**
1994 Primary Release Groups (Weighted Means - Smith et al. 1998, Tables E1 and E2)	Silcott Island (LGR Reservoir) - Lower Monumental Dam	3	0.590 **(0.838)** (Hatchery) [4/23-5/16]	**0.243** (H)	0.645 **(0.864)** (Hatchery) [4/16-5/11]	**0.311** (H)	**-0.026** **(-0.068)** (H)
1994 Snake Trap Releases (Weighted Means - Smith et al. 1998, Table E8)	Snake Trap (Above LGR Reservoir) - Lower Monumental Dam	3	0.351 **(0.705)** (Hatchery) [4/13-7/8] 0.515 **(0.802)** (Wild) [4/13-7/5]	**0.061** (H) **0.171** (W)	0.571 **(0.823)** (Hatchery) [4/13-7/6] 0.580 **(0.834)** (Wild) [4/13-7/6]	**0.210** (H) **0.234** (W)	**-0.118** **(-0.149)** (H) **-0.032** **(-0.063)** (W)
1995 Primary Release Groups (Weighted Means - Smith et al. 1998, Tables E1 and E2)	Port of Wilma (LGR Reservoir) - Lower Monumental Dam	3	0.788 **(0.924)** (Hatchery) [4/22-5/12]	**0.531** (H)	0.779 **(0.920)** (Hatchery) [4/9-5/5]	**0.513** (H)	**0.004** **(0.018)** (H)

Table 8. Seasonal average estimates of survival of yearling chinook and steelhead released in the Snake River, ascertained from PIT-tagging 1994-1996. A "project" refers to a dam + reservoir combination and a "reach" refers to river segment composed of one or more projects. Estimates in normal typeface are those reported in cited research. **Bold estimates are calculated in this table as: Mean Per-Project Survival = (Reach Survival)$^{-(\text{Number of Projects})}$; Approximate Eight-Project Survival = (Mean Per-Project Survival)^{8}.**

1995 Snake Trap Releases (Weighted Means - Smith et al. 1998, Table E9)	Snake Trap (Above LGR Reservoir) - Lower Monumental Dam	3	0.752 **(0.909)** (Hatchery) [3/31-5/31] 0.790 **(0.924)** (Wild) [3/31-5/31]	**0.466** (H) **0.531** (W)	0.729 **(0.900)** (Hatchery) [3/31-5/31] 0.844 **(0.945)** (Wild) [3/31-5/31]	**0.430** (H) **0.636** (W)	**0.009** **(0.036)** (H) **-0.021** **(-0.105)** (W)
1995 Weekly Transport + Other Fish Release Groups (Unweighted Means - S. Smith, pers. comm 1998)	Lower Granite Dam - McNary Dam	4.5	0.592 **(0.890)** (Mixed) [4/9-5/27]	**0.394** (M)	0.624 **(0.901)** (Mixed) [4/4-6/12]	**0.434** (M)	**-0.011** **(-0.040)** (M)
1996 Weekly Transport + Other Fish Release Groups (Unweighted Means - S. Smith, pers. comm 1998)	Lower Granite Dam - McNary Dam	4.5	0.615 **(0.899)** (Mixed) [4/11-5/29]	**0.427** (M)	0.587 **(0.888)** (Mixed) [4/16-5/27]	**0.387** (M)	**0.011** **(0.040)** (M)
1996 Snake Trap Releases (Weighted Means - Smith et al. 1998, Table 24)	Snake Trap (Above LGR Reservoir) - Lower Monumental Dam	3	0.954 **(0.984)** (Hatchery) [4/15-5/15] 0.951 **(0.983)** (Wild) [4/15-5/15]	**0.879** (H) **0.872** (W)	0.703 **(0.889)** (Hatchery) [4/8-5/15] 0.963 **(0.988)** (Wild) [4/5-5/15]	**0.390** (H) **0.908** (W)	**0.095** **(0.489)** (H) **-0.012** **(-0.036)** (W)
1997 Preliminary Information (Schiewe 1997b)	Lower Granite Dam - McNary Dam	4.5	0.640 **(0.906)** (Hatchery)	**0.454** (H)	0.672 **(0.915)** (Mixed)	**0.491** (M)	**-0.009** **(0.037)** (M)

Direct Transportation Survival PATH has estimated that direct survival of yearling chinook salmon during transportation is high, and an estimate of 98 percent has been used in modeling (Marmorek and Peters 1998 - DRAFT). There are no studies in which direct transportation survival of steelhead has been empirically estimated, but it is likely that 98 percent is also a reasonable estimate for steelhead direct transport survival.

Combined Transport and In-River Direct Survival Under Interim Operations Passage model estimates of combined transported and in-river migrant Snake River steelhead and chinook survival to below Bonneville Dam were not conducted for this biological opinion, but are expected to be available within the next 1 to 2 years from PATH. In the absence of detailed passage modeling, a very simple analysis to compare steelhead and chinook survival under recent conditions indicates that direct survival to below Bonneville Dam is at least as high for juvenile steelhead as it is for juvenile spring/summer chinook salmon under the interim operation. The elements of this analysis are: (1) the range of in-river survivals estimated in **Table 8**; (2) the direct transport survival rate estimated above (98 percent for each species); and (3) the relative proportion of fish entering the Lower Granite pool that are transported.

Graves and Ross (1998) estimate that under recent interim operations a larger proportion of wild Snake River steelhead than wild Snake River spring/summer chinook salmon have been transported from the Snake River (**Table 9**). Estimates range from 3 to 23 percent more steelhead transported than chinook, depending upon fish guidance assumptions and annual operations. These estimates are based on the proportion of juveniles arriving at Lower Granite Dam and therefore over-estimate the proportion of Lower Granite reservoir arrivals that are transported. Iwamoto et al. (1994) and Muir et al. (1995) suggest that most of the Lower Granite combined reservoir and dam reach mortality during the spring occurs at the dam, with little occurring in the reservoir. Some previous PATH analyses have considered 95 percent to be a conservative approximation of spring/summer chinook survival through Lower Granite reservoir (Chapter 6 of Marmorek et al. 1996).

The above information can be combined as follows:

$$S_{DIRECT} = [T \times S_{LGR} \times S_{TRAN}] + [(1-(T \times S_{LGR})) \times S_{INRIVER}]$$

(1)

where S_{DIRECT} is direct survival to below Bonneville Dam; T is the proportion of fish arriving at Lower Granite Dam that are subsequently collected for transportation from all collector projects (**Table 9**); S_{LGR} is the survival from the head of Lower Granite reservoir to Lower Granite Dam (assumed to be 0.95 for this analysis - see above); S_{TRAN} is direct survival of transported fish from collection until release (assumed to be 0.98 in this analysis - see above); and $S_{IN\text{-}RIVER}$ is direct survival of non-collected fish that migrate in-river (0.8 times estimates in **Table 8 - see above**). Combining the ranges of estimates for wild steelhead and spring/summer chinook in

Table 9. Estimates of percentage of smolts arriving at Lower Granite Dam that have been transported from Snake River collector projects during the last three years of interim operations (Graves and Ross 1998). Results for two assumptions regarding fish guidance efficiency (FGE) are presented. In one, extended-length bar screens are assumed to have the same FGE as standard travelling screens (ESBS=STS), and in the second the FGE of extended-length screens is assumed to be higher (STS<ESBS). H = hatchery; W = wild.

Year	Snake River Steelhead		Snake River Yearling Chinook		Difference (SH-CH)	
	STS=ESBS	**STS<ESBS**	**STS=ESBS**	**STS<ESBS**	**STS= ESBS**	**STS< ESBS**
1995	0.800 (H) 0.919 (W)	N/A	0.583 (H) 0.674 (W)	N/A	0.22H 0.23W	N/A
1996	0.550 (H) 0.641 (W)	0.550 (H) 0.641 (W)	0.341 (H) 0.422 (W)	0.460 (H) 0.597 (W)	0.21H 0.22W	0.09H 0.06W
1997	0.498 (H) 0.579 (W)	0.498 (H) 0.579 (W)	0.318 (H) 0.389 (W)	0.426 (H) 0.552 (W)	0.18H 0.19W	0.07H 0.03W

Tables 8 and 9 allows estimates of direct survival in 1995 and 1996 for wild smolts of each species, using comparable methods. **Table 10** indicates that, under the interim action, direct survival to below Bonneville Dam during those years was at least as high, and possibly somewhat higher, for juvenile steelhead as it is for juvenile spring/summer chinook salmon.

<u>Combined Transport and In-River Direct+Indirect Survival Under Interim Operations</u> Analyses to this point assume that effects of the FCRPS end when smolts pass, or are released from transport, immediately below Bonneville Dam. Various indirect effects of the FCRPS have been proposed beyond this point, and several hypotheses are being articulated and evaluated by the PATH process (Marmorek and Peters 1998 - DRAFT). Results are expected to be available within the next 1 to 2 years.

One type of information that is useful in evaluating indirect effects is transport studies that include survival through the estuarine and ocean environments. Recent studies (since 1986) comparing transported and in-river migrating Snake River steelhead and Snake River spring/summer chinook survival indicate higher returns of transported than non-transported juveniles for both species (summarized in **Table 11**). The transported:in-river return rate (T/I return rate) for Snake River steelhead and Snake River spring/summer chinook salmon in these studies varies slightly, but is generally similar for both species. Results of more recent transport studies, conducted in 1995 and 1996, will become available as adults return during the next three years.

Table 10. Estimates of direct survival to below Bonneville Dam of transported and non-transported wild Snake River steelhead and wild Snake River spring/summer chinook salmon. **The purpose of this table is to compare relative survival of the two species in recent years, using similar techniques - it is not to make predictions regarding future survival.** In-river survival of wild fish is from **Table 8**; transport proportions are from **Table 9**; and direct survival estimates are from Equation 1, with constants defined as in text. Complete information for wild fish in 1994 and 1997 is not available at this time.

	Steelhead			Spring/Summer Chinook			Difference in Direct Survival (SH-CH)
Year	In-River Survival	Transport Proportion	Direct Survival	In-River Survival	Transport Proportion	Direct Survival	
1994	0.8*0.171			0.8*0.234			
1995	0.8*0.531	0.919	0.910	0.8*0.636	0.674	0.811	0.099
1996	0.8*0.872	0.641	0.870	0.8*0.908	0.422 to 0.597	0.828 to 0.870	-0.001 to +0.041
1997		0.579			0.389 to 0.552		

Table 11. Summary of recent studies comparing survival of transported vs in-river migrants for Snake River steelhead and Snake River spring/summer chinook salmon. All transported fish were barged, rather than trucked. 95 % Confidence Intervals in parentheses.

Study	Steelhead Transport:In-River Return Rate	Yearling Chinook Transport:In-River Return Rate	Difference (SH-CH)
Matthews et al. (1992) Mixed Hatchery/Wild	2.0 (1.4-2.7)	1.6 (1.01-2.47)	0.4
Harmon et al. (1995) Mixed Hatchery/Wild	2.1 (1.3-3.5)	2.4 (1.4-4.3)	-0.3

In-River Survival Under Long-Term Actions

Drawdown Long-Term Action. Estimates of the in-river survival of Snake River steelhead through the FCRPS that may occur as a result of drawdowns or future project passage improvements are not presently available. Such estimates are expected within the next 1 to 2 years from the PATH analytical group. However, it is likely that drawdowns will affect juvenile steelhead in a similar manner to Snake River spring/summer chinook salmon. For example, **Table 12** indicates that survival of both yearling chinook and steelhead through free-flowing reaches of the Snake River above Lower Granite Dam are variable, with steelhead survival higher in three of the available years and yearling chinook survival higher in one year. Under the assumption that survival in a future drawn-down section of the Snake River will (after some equilibration period) be similar to survival in upstream free-flowing reaches, **Table 12** suggests that steelhead direct survival through that reach may be between 7.5 percent lower to 12.5 percent higher than chinook survival, and will average approximately 2 percent higher. Effects of drawdowns on steelhead vs chinook indirect (below Bonneville) survival cannot be described at this time.

Transport In-River Action. Estimates of the in-river survival of Snake River steelhead through the FCRPS that may occur as a result of maximizing transportation and implementing future project passage improvements are not presently available and are also expected within 1 to 2 years from the PATH analytical group. However, it is likely that these measures will affect juvenile steelhead in a similar manner to Snake River spring/summer chinook salmon. A higher percentage of juveniles will be transported under this option, leaving fewer to migrate in the river. Because spill may be curtailed at collector projects, it is likely that survival of non-transported fish remaining to migrate in-river will be reduced unless passage improvements at non-collector projects can offset this effect. Because, as described above, steelhead and chinook appear to be affected similarly by spill and turbine passage, and because steelhead appear to have slightly higher survival than chinook through bypasses, the relative impact of the long-term transportation action on in-river survival should be similar for each species. If guidance remains higher for steelhead than for yearling chinook with future collection facilities, more steelhead than chinook smolts will be transported and therefore direct survival of steelhead will be as high or higher than that of chinook, as described above. Effects of maximum transportation on steelhead vs chinook indirect (below Bonneville) survival cannot be described at this time.

Table 12. Estimates of wild juvenile steelhead and wild yearling chinook survival in free-flowing river sections above Lower Granite Dam. Estimates of survival from Whitebird (Salmon Trap) to Lower Granite (LGR) tailrace and from the head of LGR reservoir (Snake Trap) to LGR dam from Table 24 and Appendix Tables E7-E9 of Smith et al. (1998). These estimates do not necessarily reflect survival of the same population of fish through the two reaches, so the method of removing effects of LGR reservoir and dam passage in Column (3) is imperfect. **Bold estimates** are those which appear to be extremely high, possibly due to the methodology used in this table and, in the case of the 1996 estimate, due to high standard error associated with the original reach survival estimate.

	(1) Whitebird (Salmon River) to LGR Tailrace (233 km)		(2) Head of LGR Reservoir to LGR Tailrace (52 km)		(3) = (1)/(2) Estimated Survival Whitebird to Head of LGR Reservoir (181 km)		(4) = Mean per-km survival from (3) raised to 210th power Estimated Survival Through Snake Drawdown Section (210 km)		
Year	**Steelhead**	**Chinook**	**Steelhead**	**Chinook**	**Steelhead**	**Chinook**	**Steelhead**	**Chinook**	**Difference (SH - CH)**
1993	0.832	0.832	0.898	0.839	0.927	**0.992**	0.915	**0.990**	**-0.075**
1994	0.75	0.788	0.836	0.894	0.897	0.881	0.882	0.864	0.018
1995	0.892	0.863	0.955	0.944	0.934	0.914	0.924	0.901	0.023
1996	**0.967**	0.882	0.945	0.964	**1.023**	0.915	**1.027**	0.902	**0.125**

VI.A.3.c.1)b) Juvenile Upper Columbia River Steelhead

Reach survival estimates for juvenile Upper Columbia River steelhead are currently unavailable. Between 1985 through 1987 the Fish Passage Center estimated survival through the mid-Columbia River above McNary Dam, but the reach did not include passage through federal projects and the authors believed that the estimates were biased due to differential smoltification of steelhead in the upriver and downriver paired releases (FPC 1988). The best available information for survival of juvenile Upper Columbia River steelhead through federal projects in the lower Columbia River is extrapolation of survival estimates from Snake River steelhead. As described above, it appears that in-river survival of juvenile wild steelhead is slightly lower than that of juvenile wild spring/summer chinook salmon passing through the same reach. Because there will be no transportation of Upper Columbia steelhead until an apparent problem at McNary Dam has been either corrected or shown to be insubstantial, direct survival of Upper Columbia steelhead to below Bonneville Dam is also expected to be lower than that of spring/summer chinook salmon passing through the same reach. As with Snake River steelhead, indirect survival is unknown at present.

It is likely that juvenile Upper Columbia River steelhead will be affected by long-term actions in a manner similar to both Snake River steelhead and Snake River spring/summer chinook salmon. Estimates of steelhead and yearling chinook survival through free-flowing sections of the lower Columbia River are not available. However, it is likely that the difference in survival between the two species through drawn down sections of the lower Columbia River would be no greater than the difference in survival through free-flowing regions of the Snake River, as described above. Similarly, it is likely that once experiments have determined the nature of apparent collection and transportation problems at McNary Dam and either corrected them or shown them to be insubstantial, maximum transportation at McNary would provide survival through the lower Columbia River for steelhead, similar to that experienced by chinook. Steelhead transportation studies have not been conducted from McNary Dam under recent conditions, but earlier studies of transport from McNary showed that steelhead T:I ratios of 1.3 to 3.0 in 1978 through1980 encompassed the range of yearling chinook T:I ratios from that project (means of 1.6 in 1987 through 1988, 95 percent CI 1.0 to 2.25) (**Appendix B**).

VI.A.3.c.1)c) Juvenile Lower Columbia River Steelhead

Reach survival estimates for juvenile Lower Columbia River steelhead are currently unavailable. Based on studies of Snake River steelhead, it is likely that survival of wild Lower Columbia River steelhead through Bonneville Dam and reservoir is slightly lower than that of wild yearling chinook salmon. Because Lower Columbia River steelhead pass, at most, one FCRPS project, neither transportation or future drawdowns are necessary to ensure that their survival through the FCRPS is higher than that of other stocks, which must pass through 4-8 federal projects.

VI.A.3.c.2) Adults of All Species

Estimates of upriver survival under interim operations are presented for each species in section VI.A.2.c.2) for each steelhead ESU. Under a long-term drawdown scenario, survival of Snake River steelhead should increase substantially, depending upon the number of projects that are breached. If four Snake River projects are drawn down, adult mortality of Snake River steelhead above McNary Dam would be reduced from approximately 17 percent currently to a very low level - possibly near zero. This reduction would be nearly identical to that experienced by adult chinook salmon (Table 7). A drawdown of John Day or McNary would increase survival of this ESU additionally, as it would the Upper Columbia steelhead ESU. The Lower Columbia River steelhead ESU would not be affected by changes in adult survival resulting from drawdowns. It is unlikely that there would be any change in adult survival for any of the steelhead ESUs as a result of the maximum transportation long-term option.

VI.A.4. Species-Level Effects of the Proposed Action

VI.A.4.a. Snake River Steelhead

Using the interim analytical method described in Section V, the **preliminary estimate of the "target" historical smolt-to-adult return rate (SAR) range for Snake River spring/summer chinook is 2.1 to 3.8 percent (geometric mean 2.8 percent), the three most recent years' SARs, estimated by similar methods, range from 0.2 to 1.0 percent (geometric mean 0.4 percent), and the mean incremental survival change required to meet target historical SARs is 6.6 times the recent survival rates (Petrosky and Schaller 1998 - DRAFT). These estimates are currently being reviewed by a PATH subcommittee and are subject to change prior to completion of the final biological opinion.**

The **preliminary estimate of the target historical SAR range for Snake River steelhead is 3.4 to 4.2 percent (geometric mean 3.8 percent), the five most recent years' SARs, estimated by similar methods, range from 0.5 to 1.5 percent (geometric mean 0.8 percent), and the mean incremental survival change required to meet target historical SARs is 4.6 times the recent survival rates (Petrosky 1998 - DRAFT). These estimates are currently being reviewed by a PATH subcommittee and are subject to change prior to completion of the final biological opinion.**

This preliminary analysis suggests that, given the assumptions of the interim method described in Section V, the incremental change in survival required for Snake River steelhead to achieve an acceptable probability of survival and recovery is no greater than that required for Snake River spring/summer chinook salmon, and possibly less. Because the proposed action has already been determined not to jeopardize listed Snake River spring/summer chinook salmon, this conclusion implies that, if the proposed action affects Snake River steelhead survival in the action area in the same manner as it affects Snake River spring/summer chinook survival, the proposed action also will not jeopardize Snake River steelhead.

[Note: Using the alternative SAR definition supported by the tribal PATH representative, this same conclusion regarding the relative incremental survival changes needed for Snake River steelhead vs. spring/summer chinook is reached. In this case, the preliminary estimate of the mean incremental survival change required to meet target historical SARs is 3.8 times the recent survival rates for steelhead and 10.7 times the recent survival rates for spring/summer chinook salmon (Petrosky and Schaller 1998 - DRAFT).]

VI.A.4.b. Upper Columbia River Steelhead

Using the interim analytical method described in Section V, the **preliminary estimate of the "target" historical smolt-to-adult return rate (SAR) range for Snake River spring/summer chinook is 2.1 to 3.8 percent (geometric mean 2.8 percent), the three most recent years' SARs, estimated by similar methods, range from 0.2 to 1.0 percent (geometric mean 0.4 percent), and the mean incremental survival change required to meet target historical SARs is 6.6 times the recent survival rates (Petrosky and Schaller 1998 - DRAFT). These estimates are currently being reviewed by a PATH subcommittee and are subject to change prior to completion of the final biological opinion.**

The preliminary estimate of the target historical SAR range for Upper Columbia River steelhead is 1.7 to 2.9 percent (geometric mean 2.2 percent), the four most recent years' SARs, estimated by similar methods, range from 0.3 to 1.1 percent (geometric mean 0.6 percent), and the mean incremental survival change required to meet target historical SARs is 3.7 times the recent survival rates (Cooney 1998 - DRAFT). These estimates are currently being reviewed by a PATH subcommittee and are subject to change prior to completion of the final biological opinion.

This preliminary analysis suggests that, given the assumptions of the interim method described in Section V, the incremental change in survival required for Upper Columbia River steelhead to achieve an acceptable probability of survival and recovery is no greater than that required for Snake River spring/summer chinook salmon, and possibly less. Because the proposed action has already been determined not to jeopardize listed Snake River spring/summer chinook salmon, this conclusion implies that, if the proposed action affects Upper Columbia River steelhead survival in the action area in the same manner as it affects Snake River spring/summer chinook survival, the proposed action also will not jeopardize Upper Columbia River steelhead.

VI.A.4.c. Lower Columbia River Steelhead

It has not been possible to develop an interim analytical method to assess effects of the proposed action on species-level biological requirements of Lower Columbia River steelhead. However, qualitative considerations suggest that the proposed action is not likely to reduce the ability of this species to meet species-level biological requirements. Lower Columbia River steelhead pass, at most, one FCRPS project and therefore experience much less direct passage mortality than other listed ESUs considered in this biological opinion. Presumably, other sources of mortality play a greater role in determining whether this species will survive and recover than does operation of the FCRPS.

VI.A.5. Cumulative Effects

Cumulative Effects are defined in 50 CFR 402.02 as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation." For the purposes of this analysis, the action area encompasses the Snake and Columbia Rivers, including areas outside the range of listed Snake River salmon that affect natural runoff of water into those areas that are within the listed species' range. Future Federal actions, including the ongoing operation of hatcheries, fisheries, and land management activities are being or have been reviewed through separate section 7 consultation processes. This includes consultation on the operation of five mid-Columbia River Public Utility District projects, for which a section 7 consultation through the Federal Energy Regulatory Commission is anticipated. In addition, non-Federal actions that require authorization under section 10 of the ESA will be evaluated under section 7 consultations. Therefore, these actions are not considered cumulative to the proposed action.

VI.B. Effects of NMFS' Issuance of Section 10 Permits For Transportation and the Smolt Monitoring Program

VI.B.1. Effects of Modification of the Section 10 Permit for the Juvenile Transportation Program on All Species

The juvenile transportation program is an integral component of the proposed action during the interim period, as described in 1995 RPA 4 and supplemental proposed actions in this biological opinion. Issuance of the Section 10 permit for the transportation program is necessary to implement the proposed action. Effects of bypass and collection of smolts on Snake River steelhead, Upper Columbia River steelhead, and Snake River spring/summer chinook survival are described in Section VI.A.2.c.1). Effects of adult fallback through bypasses is assessed in Section VI.A.2.c.2). Effects of transportation, in terms of direct survival to below Bonneville Dam and in terms of relative survival to adults compared to in-river migrants, is compared in Section

VI.A.3.c. Details regarding all aspects of the transportation program and its effect upon listed steelhead and salmon are included in ***Appendix B***.

VI.B.2. Effects of Modification of the Section 10 Permit for the Smolt Monitoring Program on All Species

The smolt monitoring program is an integral component of the proposed action, as described in 1995 RPA 13a. Issuance of the Section 10 permit for the smolt monitoring program is necessary to implement the proposed action. Effects of bypass and collection of smolts on Snake River steelhead, Upper Columbia River steelhead, and Snake River spring/summer chinook survival are described in Section VI.A.2.c.1). Effects of adult fallback through bypasses is assessed in Section VI.A.2.c.2).

VII. FRAMEWORK COORDINATION

An April 24, 1996, letter from M. Fuhrman (COE) to W. Stelle (NMFS) and a November 14, 1996, letter from W. Stelle (NMFS) to B. Bohn (COE) outlined and implemented a “Framework” process for documenting the adaptive management process envisioned in the 1995 RPA 26. Under the Framework process, NMFS reviews implementation of measures specified in the 1995 RPA and reviews schedule changes and RPA modifications resulting from new technical or economic considerations. In the November 14, 1996, letter NMFS analyzed proposed schedule changes with respect to: (1) NMFS’ ability to make decisions or implement long-term survival options according to the schedule called for in the 1995 FCRPS Biological Opinion; and (2) effects of each schedule change on survival of listed Snake River salmon during the interim period. NMFS concluded that several schedule changes considered in that letter would not reduce NMFS’ ability to make long-term decisions and would have only minor effects on interim survival. Therefore, NMFS concluded that the schedule changes considered in November 1996 did not affect the 1995 FCRPS Biological Opinion’s conclusion that the 1995 RPA is not likely to jeopardize listed Snake River salmon.

The Action Agencies’ Biological Assessment reviews the current status of each 1995 RPA measure and notes that several schedule changes have been implemented following discussions in the System Configuration Team and Implementation Team. NMFS has reviewed these changes and noted the reasons and documentation of discussions in regional forums. Additionally, the Action Agencies’ are considering several new supplemental measures that are expected to increase survival of listed Snake River salmon, including increased spill at several projects during the interim period. In net effect, adaptive management revisions to the 1995 RPA to date will not reduce NMFS’ ability to make long-term decisions and will have minor effects on the interim survival of listed Snake River salmon. Therefore, NMFS concludes that the current implementation of 1995 RPA measures, including the supplemental measures considered in this biological opinion, is consistent with our expectations from the 1995 FCRPS Biological Opinion. Further consultation for Snake River spring/summer chinook salmon, Snake River fall chinook salmon, and Snake River sockeye salmon is not necessary at this time.

VIII. CONCLUSIONS

The method used for evaluating whether the proposed action would jeopardize listed species was described in Section V. Conclusions of this analysis regarding the effect of the proposed action for each species are presented in this section within the context of step V.D: determine the likelihood that the species can be expected to survive, with an adequate potential for recovery, under the effects of the proposed or continuing action, the environmental baseline, and any cumulative effects, and considering measures for survival and recovery specific to other life stages. Specific decision elements necessary to reach a conclusion relative to step V.D are described for each species.

VIII.A. Snake River Steelhead

VIII.A.1. Determine Significance of the Aggregate Effect Upon the Particular Biological Requirements of the Listed Species In the Action Area (V.D.1)

As stated in Section V, the biological requirements of juvenile and adult Snake River steelhead and Snake River chinook species are the same within the action area. Thus, the action will not be likely to jeopardize Snake River steelhead if the change in survival associated with the action is the same or greater for steelhead, relative to chinook.

<u>Interim Actions To Reduce Mortality of Listed Fish and To Support the Long-Term Decision</u>

Side-by-side analyses of the survival of Snake River steelhead and Snake River juvenile and adult chinook salmon through project routes, FCRPS reaches, and transportation indicate that, during the time period that the steelhead and chinook migrations overlap, the two species experience similar effects of the FCRPS, including the measures to improve survival set out in the 1995 RPA and the proposed supplemental actions. The in-river survival of juvenile steelhead appears to be slightly lower than that of chinook. However, because fish guidance efficiencies are generally higher for steelhead, the direct survival of outmigrating smolts to below Bonneville Dam is at least as high (and probably higher) for steelhead than for chinook. Indirect mortality below Bonneville Dam resulting from passage through the FCRPS is undetermined for each species, but is the subject of ongoing analyses by the PATH analytical team (Marmorek et al. 1998 - DRAFT). Until this analysis is completed, NMFS assumes that the level of indirect mortality, if any, is similar for the two species. Adult passage mortality of both Snake River steelhead and Snake River chinook is very similar for the two species, as described in Section VI, so both species are likely to have similar changes in adult survival as a result of the proposed action.

The timing and geographical range of measures to reduce FCRPS mortality appear to be sufficient for similar protection of juvenile Snake River steelhead, compared to protection of juvenile Snake River spring/summer chinook salmon. For example, in response to the slightly earlier arrival timing of steelhead smolts at Lower Granite Dam, the Action Agencies have included a supplemental proposed action to move the initiation of the Lower Granite spring spill planning date from April 10 to April 3.

All reasonable measures to reduce hydrosystem mortality are being implemented under the proposed action, consistent with the intent of the interim measures called for in the 1995 RPA. In addition to implementing the 1995 RPA, the proposed action includes supplemental measures to increase spill at several projects, intended to increase the survival of non-transported fish, and a measure to reduce the proportion of transported fish that are trucked, intended to reduce the mortality and straying rate of transported fish.

<u>Long-Term Major Structural Improvements To the FCRPS</u>

The long-term measures described in the 1995 RPA should result in similar reductions in mortality for Snake River chinook and Snake River steelhead. Both species currently experience similar effects of transportation from the Snake River and should respond similarly under a long-term operation that maximizes transportation. A comparison of survival rates estimated for juvenile chinook and steelhead in free-flowing reaches of the Snake River (Section VI) suggests that the two species will experience similar effects of drawdowns.

VIII.A.2. Evaluate Effects of the Proposed Or Continuing Action In the Context of the Full Life Cycle to Determine If Species-Level Biological Requirements Are Likely To Be Met (V.D.2)

As described in Section V and Section VI.A.4, life-cycle analyses that estimate the probability of survival and recovery of Snake River steelhead are not possible at this time. The interim analysis applied in this supplemental opinion was described in previous sections but is summarized again here because it is a necessary departure from the analysis performed for the 1995 FCRPS Biological Opinion.

The interim analysis assumes that the smolt-to-adult (SAR) survivals of Snake River spring/summer chinook and Snake River steelhead during a historical period correspond to survival rates that represent acceptable probabilities of survival and recovery. This assumption, that historical SAR rates can be used as a proxy for acceptable probabilities of survival and recovery, has been partially validated for Snake River spring/summer chinook salmon by PATH (Marmorek et al. 1998 - DRAFT). However, this assumption has not been validated for steelhead.

A second assumption of this methodology is that, because the proposed action (including long-term measures, assumptions about survival changes in other parts of the life cycle, and assumptions about climate variability) has been determined not to jeopardize Snake River spring/summer chinook salmon (i.e., to result in acceptable probabilities of survival and recovery), the proposed action can be assumed to result in a survival change sufficient to bring recent Snake River spring/summer chinook SARs to the historical target SAR level.

The third assumption of this methodology is that the incremental change between current and target historical Snake River steelhead SAR levels is equal to or less than the incremental change necessary for Snake River spring/summer chinook salmon. This assumption is currently being evaluated by a subcommittee of PATH. Preliminary results are described in Section VI.A.4 and below. If this third assumption is correct, then the proposed action is likely to result in achievement of historical target SARs for Snake River steelhead (i.e., not jeopardize steelhead) if the change in survival within the action area is the same or greater for steelhead, compared to chinook (as discussed in VIII.A.1). Conversely, if the incremental change between recent and historical steelhead SARs is greater than the incremental change needed by chinook, the proposed action will have to result in a greater increase in steelhead survival within the action area, compared to the increase in chinook survival.

The preliminary conclusions of the interim analysis described in Section VI.A.4 indicate that the incremental change in SARs necessary for steelhead is less than or equal to that necessary for Snake River spring/summer chinook salmon, which supports the third assumption. When this information is combined with conclusions of VIII.A.1, which indicate that survival effects within the action area will be the same or greater for Snake River steelhead than for Snake River spring/summer chinook salmon, it appears that the proposed action is likely to result in achievement of historical SARs for Snake River steelhead. Based upon the first assumption, this suggests that species-level biological requirements of Snake River steelhead are likely to be met under the proposed action.

The Action Agencies' proposed action contains a commitment to continue to fund analytical work to improve upon the interim method for assessing the effects of the proposed action on the species-level biological requirements addressed in this supplemental opinion. These efforts should be timed to ensure the availability of an improved analytical method prior to reconsultation on this action after a decision is made regarding the long-term configuration of the FCRPS at the end of 1999.

VIII.A.3. Summary of Conclusions for Snake River Steelhead

The NMFS has determined that, based on the available information, the proposed operation of the FCRPS by the Action Agencies, as described in Section III.A, and the issuance of two Section 10 research and enhancement permits by NMFS in support of transportation and smolt monitoring, as described in Section III.B, is not likely to jeopardize the continued existence of Snake River steelhead. This conclusion is based upon consideration of the effect of the proposed actions on biological requirements within the action area and throughout the life cycle, as summarized in Sections VIII.A.1 and VIII.A.2.

VIII.B. Upper Columbia River Steelhead

VIII.B.1. Determine Significance of the Aggregate Effect Upon the Particular Biological Requirements of the Listed Species In the Action Area (V.D.1)

As stated in Section V, the biological requirements of juvenile and adult Upper Columbia River steelhead and Snake River chinook species are the same within the action area. The same considerations for assessing effect of the proposed action on the biological requirements of Snake River within the action area apply to Upper Columbia River steelhead.

<u>Interim Actions To Reduce Mortality of Listed Fish and Support the Long-Term Decision</u>

As described in Section VI.A.3.c.1)b), the best available information on the survival of juvenile Upper Columbia River steelhead through federal projects in the lower Columbia River is obtained by extrapolating estimates of reach survival from those measured for juvenile Snake River steelhead and by using site-specific passage estimates for lower Columbia River projects. These data indicate that, during the period that the steelhead and chinook migrations overlap, the two species experience similar effects of the FCRPS, including the effects measures to improve survival set out in the 1995 RPA and supplemental actions proposed in this supplemental opinion. Based on the estimates in **Table 8**, the in-river survival of juvenile steelhead appears to be slightly lower than that of chinook. Because transportation from McNary Dam is currently not available, direct survival to below Bonneville Dam is also likely to be slightly lower for Upper Columbia River steelhead than for Snake River chinook passing through lower Columbia River projects. Experimental transportation from McNary Dam after 1998, and correction of what appears to be a problem with collection and transportation of spring migrants from that project, should result in comparable direct rates of survival for the two species in the future. Indirect mortality below Bonneville Dam resulting from passage through the FCRPS is undetermined for either species, but is the subject of ongoing analyses by the PATH analytical team (Marmorek et al. 1998 - DRAFT). Until these analysis are completed, NMFS assumes that indirect mortality, if any, is similar for the two species. Adult passage mortality of both Upper Columbia River steelhead and Snake River chinook through lower Columbia River projects is very similar for the two species, as described in

Section VI, so both species are likely to have similar changes in adult survival as a result of the proposed action.

The timing and geographical range of measures to reduce FCRPS mortality appear to be sufficient for similar protection of juvenile steelhead, compared to protection of juvenile Snake River spring/summer chinook salmon. For example, the Action Agencies have proposed a mid-Columbia flow objective for the period April 10 to June 30 to match available water to the timing of smolt migration for this species.

All reasonable measures to reduce hydrosystem mortality will be implemented under the proposed action, consistent with the intent of the interim measures called for in the 1995 RPA. In addition to implementing the 1995 RPA, the proposed action includes supplemental measures to increase spill at several projects, intended to increase the survival of non-transported fish through the lower Columbia River projects. Once transportation begins from McNary, another supplemental measure will reduce the proportion of transported fish that are trucked, in order to reduce the mortality and stray rate of transported fish.

Long-Term Major Structural Improvements To the FCRPS

The long-term drawdown measures described in the 1995 RPA will not affect the survival of Upper Columbia River steelhead. However, the Action Agencies' provide a comparable long-term action which will affect Upper Columbia River steelhead by including in the proposed action a commitment to evaluate alternatives for the long-term operation of FCRPS projects on the lower Columbia River (including natural river drawdowns). As described in Section VI.A.3.c.1)b), Snake River chinook and Upper Columbia River steelhead should experience similar changes in survival as a result of either the drawdown or maximum transportation long-term actions.

VIII.B.2. Evaluate Effects of the Proposed Or Continuing Action In the Context of the Full Life Cycle to Determine If Species-Level Biological Requirements Are Likely To Be Met (V.D.2)

The evaluation of the effects of the proposed action on the species-level biological requirements of Upper Columbia River steelhead is the same as that described in Section VIII.A.2 for Snake River steelhead. The preliminary conclusions of the interim analysis, described in Section VI.A.4, indicate that the incremental change in SARs necessary for Upper Columbia River steelhead is less than or equal to that necessary for Snake River spring/summer chinook salmon, supporting the third assumption set out in Section VIII.A.2 (above). When this information is combined with conclusions of VIII.B.1, which indicate that survival effects within the action area will be the same or greater for Upper Columbia River steelhead compared to Snake River spring/summer chinook salmon, it appears that the proposed action is likely to result in achievement of historical SARs for Upper Columbia River steelhead. Based upon the first assumption, this suggests that species-level biological requirements of Upper Columbia River steelhead are likely to be met under the proposed action.

The Action Agencies' proposed action contains a commitment to continue to fund analytical work to improve upon the interim method for assessing the effects of the proposed action on the species-level biological requirements addressed in this supplemental opinion. These efforts should be timed to ensure the availability of an improved analytical method prior to reconsultation on this action after a decision is made regarding the long-term configuration of the FCRPS in the lower Columbia River.

VIII.B.3. Summary of Conclusions for Upper Columbia River Steelhead

NMFS has determined that, based on the available information, the operation of the FCRPS by the Action Agencies, as described in Section III.A, and the issuance of two Section 10 research and enhancement permits by NMFS in support of transportation and smolt monitoring, as described in Section III.B, is not likely to jeopardize the continued existence of Upper Columbia River steelhead. This conclusion is based upon consideration of the effect of the proposed actions on biological requirements within the action area and throughout the life cycle, as summarized in Sections VIII.B.1 and VIII.B.2.

VIII.C. Lower Columbia River Steelhead

VIII.C.1. Determine Significance of the Aggregate Effect Upon the Particular Biological Requirements of the Listed Species In the Action Area (V.D.1)

As stated in Section V, biological requirements of juvenile and adult Lower Columbia River steelhead and Snake River chinook species are the same within the action area. The same considerations for assessing effect of the proposed action on Snake River steelhead action-area biological requirements apply to Lower Columbia River steelhead.

<u>Interim Actions To Reduce Mortality of Listed Fish and Support the Long-Term Decision</u>

As described in Section VI.A.3.c.1)b), the best available information for survival of juvenile Lower Columbia River steelhead through Bonneville Dam and pool is obtained by extrapolating estimates of reach survival from those measured for juvenile Snake River steelhead and by using site-specific passage estimates developed for Bonneville Dam. This suggests that Lower Columbia River steelhead may have slightly lower survival than Snake River juvenile and adult chinook salmon through this short impounded reach. Estimates of indirect mortality below Bonneville Dam that can be attributed to passage through the FCRPS have not determined for either species, but are the subject of ongoing analyses by the PATH analytical team (Marmorek et al. 1998 - DRAFT). Until this analysis is completed, NMFS assumes that the level of indirect mortality, if any, would be similar for the two species. As described in Section VI, adult passage mortality rates for both steelhead and chinook through Bonneville Dam are very similar for the two species so it is likely that the proposed action will result in similar changes in adult survival rates.

The timing and geographical range of measures to reduce FCRPS mortality are expected to provide similar levels of protection for juvenile steelhead and juvenile Snake River spring/summer chinook salmon. All reasonable measures to reduce hydrosystem mortality will be implemented under the proposed action.

<u>Long-Term Major Structural Improvements To the FCRPS</u>

Because Lower Columbia River steelhead pass no more than one FCRPS project, neither transportation or future drawdowns are necessary to ensure that their survival through the FCRPS is higher than that of other stocks, which must pass through four to eight federal projects.

VIII.C.2. Evaluate Effects of the Proposed Or Continuing Action In the Context of the Full Life Cycle to Determine If Species-Level Biological Requirements Are Likely To Be Met (V.D.2)

An analysis of effects of the proposed action on species-level biological requirements of Lower Columbia River steelhead was not possible for this supplemental Biological Opinion. In addition to a lack of tools for performing such an assessment, a much smaller part of the life-cycle of this ESU is influenced by FCRPS activities, compared to the other ESUs considered in this biological opinion. Therefore, knowledge of likely changes in actions affecting other parts of the life cycle is critical to performing a species-level analysis for Lower Columbia River steelhead.

In the absence of even an interim analytical method for quantifying the effect of the proposed action in the context of the life-cycle requirements of listed species, qualitative considerations lead to the conclusion that the proposed action will not appreciably reduce the ability of this ESU to survive and recover. This conclusion is based on the following considerations: (1) only two of the stocks within this ESU pass any FCRPS projects, the remaining stocks pass none; (2) these two stocks pass only one project, resulting in much lower FCRPS mortality than that experienced by Snake River chinook stocks which are not jeopardized by the proposed action; and (3) the proposed action contains several measures specific to Bonneville Dam that are designed to reduce mortality both in the interim and long-term periods and therefore to reduce the effects of the environmental baseline for this species. The Action Agencies' are also considering a proposal to fund a committee to continue analytical work to develop a method that can be used to quantitatively assess the effects of the proposed action on the species-level biological requirements of this ESU. Timing of this measure should ensure the availability of an improved analytical method prior to reconsultation on this action.

VIII.C.3. Summary of Conclusions for Lower Columbia River Steelhead

The NMFS has determined that, based on the available information, the operation of the FCRPS by the Action Agencies, as described in Section III.A, and the issuance of two Section 10 research and enhancement permits by NMFS in support of transportation and smolt monitoring, as described in Section III.C, is not likely to jeopardize the continued existence of Lower Columbia River steelhead. This conclusion is based upon consideration of the effect of the proposed actions on biological requirements within the action area and throughout the life cycle, as summarized in Sections VIII.B.1 and VIII.B.2.

IX. CONSERVATION RECOMMENDATIONS

Conservation recommendations are discretionary measures suggested to minimize or avoid the potential adverse effects of a proposed action on listed species, to minimize or avoid adverse modification of critical habitat, to develop additional information, or to assist the federal agencies in complying with the obligations under section 7(a)(1) of the ESA. The NMFS believes the following conservation recommendation, supplemental to those stated in the 1995 FCRPS Biological Opinion, is consistent with these obligations, and therefore supports its ongoing implementation by the Action Agencies:

Hydro-Regulation Analyses:

> The Action Agencies should continue efforts to provide infomation and common analytical methods for evaluating alternative system operations and their associated costs.

The Memorandum of Agreement concerning BPA's financial commitment for Columbia River Basin Fish and Wildlife Costs included provisions to develop and implement agreed upon and accessible common accounting methods for determining costs associated with system operations. The BPA and the Power Planning Council have now developed a Hydro regulation model that runs on a PC platform. The BPA and the Council are making this model available to users in the region and will develop arrangements to ensure that the model is kept current and available to potential users in the region. Technical workshops on the use of the model are planned to allow others in the region to become skilled, if they so desire. BPA has made funds available to each tribe in the basin which may be used to assist them in gaining technical skills, among other things.

Equally important to understanding the costs of system operations is the underlying economic analysis. Several parties in the region are engaged in developing analytic tools. BPA has continued to refine its economic spreadsheet model and will be sharing this newer version with parties during April. The Power Planning Council through its work on stranded costs is also developing tools that may be useful for estimating costs associated with operating the system. The Corps of Engineers, through its Lower Snake River Feasibility Study, is examining an additional tool that may provide insights to the costs of system operations.

X. REINITIATION OF CONSULTATION

Consultation must be reinitiated if: the amount or extent of taking specified in the Incidental Take Statement is exceeded, or is expected to be exceeded; new information reveals effects of the action may affect listed species in a way not previously considered; the action is modified in a way that causes an effect on listed species that was not previously considered; or, a new species is listed or critical habitat is designated that may be affected by the action (50 CFR 402.16).

These general conditions apply as well to prospective agreements, plans and contracts (“prospective agreements”) that the Action Agencies use to plan for operation of or to actually operate the FCRPS and to coordinate operations with Canada and regional utilities. Examples include implementation of the Columbia River Treaty (Treaty) between the United States and Canada, such as by the adoption of assured operating plans and detailed operating plans; arrangements with Canada for Non-Treaty storage; and renewing and revising the Pacific Northwest Coordination Agreement.

To the extent that the prospective agreements are used to achieve operations that are in accordance with this supplemental Biological Opinion, including reasonable and prudent measures and terms and conditions, the effects of those prospective agreements on Snake River salmon have been considered in this supplemental Biological Opinion. To the extent that proposed agreements have effects on FCRPS operations that affect listed fish in ways not considered in the supplemental opinion, or have provisions that go beyond implementing the operations specified in the supplemental opinion, those proposed actions may require separate consultation or reinitiation of this consultation.

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XII. INCIDENTAL TAKE STATEMENT

Section 9 and regulations implementing Section 4 of the ESA prohibit any taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct) of listed species without a specific permit or exemption. When a proposed Federal action is found to be consistent with Section 7 (a)(2) of the ESA (i.e., the action is found not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat) and that action may incidentally take individuals of listed species, NMFS will issue an incidental take statement specifying the impact of any incidental taking of endangered or threatened species.

The incidental take statement also provides reasonable and prudent measures that are necessary to minimize impacts, and sets forth terms and conditions with which the action agency must comply in order to implement the reasonable and prudent measures. Incidental takings resulting from the agency action, including incidental takings caused by activities authorized by the agency, are exempted from the taking prohibition by section 7 (o) of the ESA, but only if those takings are in compliance with the specified terms and conditions.

A numerical estimate of allowable incidental take has not been determined for this draft of the supplemental Biological Opinion. Future drafts will seek to better estimate the amount of take for each of the listed steelhead ESUs.

This incidental take statement supplements the 1995 FCRPS Biological Opinion. The 1995 incidental take statement shall continue in full effect except to the extent that this supplemental incidental take statement changes particular measures or establishes additional measures.

A. TERMS AND CONDITIONS

1. Flow Augmentation

1.a. The Action Agencies, in coordination with the Regional Forum, shall review the findings in the Columbia River Basin System Flood Control Review -- Preliminary Analysis Report (1997) and evaluate further steps to examine flood control operations (including the timing of operations and rule curves) in the Columbia River basin with the goal of increasing the probability of meeting spring period flow objectives for steelhead. The Action Agencies shall submit a report to NMFS recommending appropriate measures to be taken by *[date to be determined]*. After consultation with NMFS, measures shall be implemented by *[date to be determined]*.

In the Snake River, under current flood control practices, water held for flood control is often released during periods (i.e., during October or March) when it can provide relatively little benefit to migrating steelhead.

2. Project Operations

2.a. The Action Agencies, in coordination with the Regional Forum, shall investigate the cause of "headburn" in adult salmonids and shall implement corrective measures, if appropriate. The Action Agencies shall submit a report to NMFS stating the findings of this study and recommending corrective measures by *[date to be determined]*. After consultation with NMFS, measures shall be implemented by *[date to be determined]*.

The proportion of adult salmonids with headburn has exceeded *5* percent at FCRPS dams since at least 1993. The cause of headburn is unknown as is the rate of survival of affected fish. However, the cause of headburn appears to be related to dam passage and it is unlikely that many fish with this condition survive to spawn. The goal of these investigations shall therefore be to identify the cause of headburn and to identify preventative measures, to be implemented, if appropriate.

2.b. Guidelines for turbine operations within 1% peak efficiency shall be updated before March 15 of each year, through the Fish Passage Operations and Maintenance Coordination Team, with assistance from the Turbine Working Group.

The operational characteristics of turbines are under continual review in model and field studies. New information, including data on the effects of operating turbines at peak efficiency on the survival of juvenile and adult steelhead, should be reviewed on an annual basis and incorporated into the Corps' Fish Passage Plan and operational guidelines.

2.c. To improve adult fishway operations, the Action Agencies, in coordination with the Regional Forum, shall:

1) develop means for the early detection of potential diffuser grating failure in adult collection channels and ladders (including methods of measuring adult fishway auxiliary water supply system conduit pressure);
2) develop improved measures to ensure the security of diffuser gratings in adult fishways at all projects; and
3) develop an Emergency Response Plan for each FCRPS mainstem project, to be followed in the event that critical components of adult passage facilities break, washout or cease to operate.

The Action Agencies shall submit a report to NMFS stating the findings of these studies and recommends corrective measures by *[date to be determined]*. After consultation with NMFS, corrective measures (including preparation of an Emergency Response Plan for each project) shall be implemented by *[date to be determined]*.

Due to a failure of the diffuser grating, the adult fishway at Bonneville Dam Second Powerhouse malfunctioned during July 1997. Although fish loss was low, it took several weeks to develop an action plan for (1) recovering trapped adults and (2) repairing the facility. A similar incident at The Dalles Dam during 1994 resulted in hundreds of dead adult steelhead and chinook salmon (Memo for the Record dated January 18, 1994, Robert Dach, Corps of Engineers, Portland District). The condition stated above is intended to minimize the number of adult steelhead and other salmonids which might be lost during this type of malfunction.

2.d. The Action Agencies, in coordination with the Regional Forum, shall maintain fish facilities within criteria identified and operate the project within operational guidelines contained in the Corps' Fish Passage Plan. These criteria and operational guidelines will be reviewed and approved by NMFS prior to the start of each fish passage season (generally March 1).

Reasonable and Prudent Alternative measure 7 in the 1995 FCRPS Biological Opinion addressed the need to operate adult fishways within the operating criteria established in the Corps' Fish Passage Plan. Because the implementation of this plan directly affects the survival of adult and juvenile steelhead, and because this plan is included, by reference, in the 1995 FCRPS Biological Opinion, the Action Agencies will consult with NMFS regarding the operations and criteria stated in each annual plan.

2.e. The Action Agencies, in coordination with the Regional Forum, shall investigate tailrace hydraulic conditions through general model studies to determine optimum spill patterns that will minimize juvenile retention time in spill basins and tailraces and minimize adverse conditions for adult passage at all dams where this has not already been done. The Action Agencies shall submit a report to NMFS stating the findings of these investigations by *[date to be determined]*. After consultation with NMFS, corrective measures shall be implemented by *[date to be determined]*.

This work has been completed for existing conditions at Bonneville, The Dalles and John Day dams, partially completed for Ice Harbor Dam. Very little detailed information exists for McNary, Lower Monumental, Little Goose and Lower Granite dams, particularly for the potentially high percentage spills called for in this opinion. Scale model studies will allow a timely assessment of tailrace conditions in a stepwise manner through a full range of spill and total flow levels, and varied turbine unit operations. The final patterns should be verified to the extent possible through field observations after implementation.

2.f. The Action Agencies shall continue to implement adult salmonid counting programs at FCRPS dams but shall improve the reporting of these counts to NMFS. In addition to the daily counts already provided, the Action Agencies shall work through the Fish Program Operations and Maintenance Coordination Team to improve reporting of annual cumulative counts and a 10-year record of daily passage at each FCRPS project. Reporting improvements shall also include timely (i.e., within 3 days) winter passage counts for all projects where winter counting currently occurs. These changes in reporting methods shall be implemented no later than *[date to be determined]*.

Pre-spawn, summer run steelhead are abundant near McNary Dam during the late fall and early winter months. Fallback through the juvenile bypass system at McNary can exceed 50 steelhead per day during the period just prior to screen removal on December 15 (Paul Wagner, Washington Department of Fish and Wildlife, pers. comm.). Large concentrations of steelhead are also observed each winter when the adult ladders at John Day Dam are removed for maintenance. The reporting requirements described above are designed to provide the level of information needed for decision-making during both normal and emergency fish passage management and consultation, especially during the winter maintenance period.

2.g. The Action Agencies, in coordination with the Regional Forum, shall investigate and implement measures to reduce fallback mortality of upstream migrant steelhead at all lower Snake and lower Columbia River dams. These measures may include the installation of extended-length screens and extending the period during which the juvenile bypass system is in operation, at dams which have these facilities. The Action Agencies shall submit a report to NMFS stating the findings of these investigations and recommending corrective measures by *[date to be determined]*. After consultation with NMFS, corrective measures shall be implemented by *[date to be determined]*.

As described above, pre-spawn, summer run steelhead are abundant near McNary Dam during the late fall and early winter months. Large concentrations of steelhead are also noted each year when the adult ladders at John Day Dam are taken out of service for annual maintenance. Therefore, there is reason to believe that fallback at McNary and John Day Dams could be high during the period when screens are normally removed. This term/condition of the incidental take statement supplements RPA measure 8 of the 1995 FCRPS Biological Opinion to provide protection for steelhead during the winter portion of the adult migration.

2.h. The Action Agencies, in coordination with the Regional Forum, shall investigate measures to improve fish guidance efficiencies at Lower Monumental Dam, to be implemented pending the 1999 decision on the long-term operation of FCRPS projects on the Lower Columbia River. As part of the Lower Snake River Feasibility Study, the Action Agencies shall submit a recommendation of corrective measures to NMFS by *[date to be determined]*. After consultation with NMFS, corrective measures shall be implemented by *[date to be determined]*.

Recent modifications at Lower Granite, Little Goose, and Ice Harbor Dams have allowed operating gates to be raised for the purpose of increasing flows into gatewells and increasing fish guidance efficiencies.

2.i. The Action Agencies, in coordination with NMFS and the Regional Forum, shall jointly investigate operational and structural gas abatement measures at Grand Coulee and Chief Joseph Dams as part of a system-wide evaluation of gas abatement measures. The Action Agencies shall submit an interim status report to NMFS by April 1999, stating the findings of these investigations at Grand Coulee which could be incorporated into a system-wide evaluation by the end of 2000. The Action Agencies shall seek congressional authority and funding, as necessary, to implement any feasible action.

Lower dissolved gas levels from Grand Coulee and Chief Joseph Dams would reduce background dissolved gas levels in the mid-Columbia, limiting the duration of exposure of adult steelhead to high dissolved gas concentrations. Further, the passage survival of juvenile steelhead would be improved because increased spill would be allowed at downstream FCRPS projects under the current dissolved gas cap.

2.j. The Action Agencies, in coordination with the Regional Forum, shall investigate the problem of attraction and delay of adult fallbacks in specific parts of juvenile collection galleries at Ice Harbor and McNary Dams. The Action Agencies shall submit a report to NMFS stating the findings of these investigations and recommending corrective measures by *[date to be determined]*. After consultation with NMFS, corrective measures shall be implemented by *[date to be determined]*.

Adult steelhead are known to fallback and hold in collection channels at Ice Harbor and McNary Dams. In the past, some of these fish jumped out of the channels and died. Nets were installed to prevent this type of mortality. However, the adult steelhead continue to be injured as they jump against the nets. The goal of this term/condition of the Incidental Take Statement is to develop and implement further corrective measures that will reduce the injury and delay of adult steelhead.

2.k. The Action Agencies, in coordination with the Regional Forum, shall investigate and correct the problem of adult steelhead holding and jumping in the fish ladders at John Day Dam. The Action Agencies shall submit a report to NMFS stating the findings of these investigations and recommending corrective measures by *[date to be determined]*. After consultation with NMFS, corrective measures shall be implemented by *[date to be determined]*.

Adult steelhead delay is also a problem at John Day Dam where hundreds of steelhead hold in the adult fish ladders in the mid- to late-fall period. This phenomenon has been well documented by the Corps' Fishery Field Unit. Several attempts have been made to remedy this situation including reducing the amount of area available for fish to hold in and altering local hydraulic conditions to lure fish out of the area. None of these measures has been very successful and steelhead continue to hold in these areas every year. One unfortunate result of this holding is that the fish jump in the ladder pools. Jumping can cause serious injury and fatigue and, in the past, has resulted in killing a number of steelhead each year. Currently, netting keeps the fish in the ladder, but the jumping continues and a better solution to the jumping problem must be found.

2.l. The Action Agencies, in coordination with the Regional Forum and USFWS, shall install and maintain effective means of discouraging predation (e.g., water spray, avian predator lines) at all forebay, tailrace, and bypass outfall locations where avian predator activity has been observed at FCRPS dams. The Action Agencies shall submit a report to NMFS stating the findings of these investigations and recommending corrective measures by *[date to be determined]*. After consultation with NMFS, corrective measures shall be implemented by *[date to be determined]*.

Bird predation marks are among the most common injuries observed on juvenile steelhead at smolt monitoring sites. During 1995 and 1996, 15 and 10 percent, respectively, of all the hatchery steelhead examined at John Dam Dam exhibited bird predation marks (Martinson et al. 1997). These observations indicate a high rate of predation on juvenile steelhead which could be reduced with appropriate measures. The Action Agencies shall coordinate scoping and implementation of predator control measures with the USFWS to ensure that the measures to not endanger bald eagles, osprey, and other affected bird species that are afforded federal protection.

2.m. The Action Agencies, in coordination with the Regional Forum, shall investigate structural and operational measures required to begin monitoring fish passage at Lower Granite Dam no later than March 25 of each year. The Action Agencies shall submit a report to NMFS stating the findings of these investigations and recommending corrective measures by *[date to be determined]*. After consultation with NMFS, corrective measures shall be implemented by *March 25, 1998.*

Based on monitoring data from years with variable start dates, the wild steelhead outmigration past Lower Granite Dam appears to begin during the last week of March. During the period 1985 through 1997 (omitting 1993, when monitoring did not begin until April 15), the mean date of arrival for daily index counts of 100 or more wild steelhead was April 3 (Fish Passage Center, Smolt Index Report and FTOT Annual Reports, NOAA). During 1996 and 1997, more than 100 steelhead were monitored on the start dates of March 27 and 28, respectively, and during 1997 more than 2,000 steelhead were observed on March 30. Monitoring must begin by March 25 of each year to provide full information about the wild component outmigration for use in in-season management and planning.

2.n. The Action Agencies, in coordination with the Regional Forum, shall investigate turbine modifications to improve fish passage survival in the ongoing major rehabilitation program at The Dalles Dam.

Regardless of fish screens and spill programs, a large proportion (20 percent or more) of migrating juvenile steelhead pass through the turbines at FCRPS dams. The installation of turbine passage modifications that are proven to improve juvenile survival will reduce hydrosystem loss of juvenile steelhead and other salmonids. Turbine modifications (intake to draft tube exit) shall be considered for McNary, John Day, and Bonneville Dams under the Feasibility Studies for Alternative System Configurations in the Lower Columbia River. These types of modifications shall also be incorporated into the ongoing rehabilitation program at The Dalles Dam.

3. Research

<u>Flow Augmentation</u>

3.a. The Action Agencies, in coordination with the Regional Forum, shall investigate the over-winter survival and migrational timing of wild Upper Columbia River steelhead to ensure sufficiency of the mid-Columbia River spring flow objective for all listed stocks. The Action Agencies shall submit a report to NMFS stating the findings of these investigations and recommending changes to the flow objective proposed in this supplemental Biological Opinion that are merited by biological concerns, by *[date to be determined]*. Changes to the mid-Columbia flow objective shall be implemented only after coordination with NMFS through the framework process.

<u>Project Passage</u>

3.b. The Action Agencies, in coordination with the Regional Forum, shall design and implement studies to measure rates of steelhead kelt passage and adult salmonid fallback, adult guidance by juvenile fish screens, and the survival rates and injury mechanisms for adult and juvenile salmonids passing through Kaplan turbines. The Action Agencies shall submit a report to NMFS stating the findings of these investigations by *[date to be determined]*.

The passage, injury, and survival rates of steelhead and other salmonids which pass through Kaplan turbines are poorly understood. Quantitative estimates of these parameters are needed for the development of biologically-based turbine design criteria (below) which will result in reduced direct and indirect passage mortality of juvenile and adult steelhead and other salmonids.

3.c. The Action Agencies, in coordination with the Fish Passage Operations and Maintenance Coordination Team and the Fish Passage Improvement Through Turbines, Technical Work Group, shall develop and implement a program to study hydraulic and behavioral aspects of turbine passage by adult and juvenile steelhead and other salmonids through turbines for the purpose of developing biologically-based turbine design criteria. The Action Agencies shall submit a report to NMFS stating the findings of these investigations and recommending a set of biologically-based design criteria by *[date to be determined]*.

These studies shall include evaluations of prototype turbine designs and modifications to the turbine environment (intake to draft tube exit) and shall consider whether these designs are likely to improve the survival of adult and juvenile steelhead and other salmonids passing via the turbine route.

3.d. The Action Agencies shall design and implement a thorough investigation of the new minimum gap runner at Bonneville Dam First Powerhouse to ensure that the new runner environment provides improved survival for migrants that pass through turbines. The Action Agencies shall submit a report to NMFS stating the findings of these investigations by January 2001.

3.e. The Action Agencies, in coordination with the Regional Forum, shall continue to investigate the application of surface collection technologies at lower Snake and Columbia River projects including:

1) measures designed to optimize passage through the ice and trash sluiceway and spillway (The Dalles Dam) and
2) measures designed to minimize delay in the forebay, including spillway weirs and skeleton bay surface collection (John Day Dam).

The Action Agencies shall submit a report to NMFS stating the findings of these investigations by *[date to be determined]*.

3.f. The Action Agencies, in coordination with the Regional Forum, shall initiate investigations to determine the direct and indirect effects of multiple bypass systems on smolt-to-adult return rates for listed steelhead and other salmonids. The Action Agencies shall submit a report to NMFS stating the findings of these investigations by *[date to be determined]*.

Recent adult PIT-tag recoveries and calculated smolt-to-adult return rates suggest that juvenile bypass systems (especially multiple bypass systems) may not be providing the expected level of benefit to migrating steelhead and other salmonids. Because most listed smolts from the Snake and Upper Columbia River steelhead ESUs encounter one or more of these systems, it is crucial that they provide a level of benefit that results in increased direct and indirect passage survival.

Juvenile Fish Transportation

3.g. The Action Agencies, in coordination with the Regional Forum, shall initiate, during 1999, an experimental evaluation of the smolt-to-adult survival of juvenile chinook and steelhead transported from McNary Dam. Objectives of the study will include:

1) the absolute return rates of transport and inriver groups;
2) the ratios of tranport:inriver return rates and their relationships to river conditions;

3) effects of transport from McNary on homing; and
4) relationships between ratios of transport:inriver return rates and measurements of juvenile survival below McNary Dam.

The Action Agencies shall submit a report to NMFS stating the findings of these investigations by *[date to be determined]*.

NMFS' rationale for deciding not to resume spring transport operations from McNary Dam at this time stems from concerns identified in the review of adult return information from fish PIT-tagged in the Snake River during 1994 and subsequently transported from McNary Dam . These data suggest that there may be a previously undetected problem with fish that were collected at McNary Dam in the juvenile facility that became operational during 1994. The problem may affect all fish entering the bypass, not just those that that are transported.

NMFS is also concerned with the lack of any recent information on transport from McNary Dam. In view of significant improvements in passage downstream of McNary, and the higher proportion of Snake River fish already being barged without additional transport from McNary, NMFS believes it prudent to approach any resumption of spring transport from McNary as a research experiment focused on the response of fish originating in the Columbia River above the confluence with the Snake River.

As described by the ISAB (1998), comparisons of transported and in-river fish should be evaluated by returns to the spawning grounds of individual stocks, where the effects of transport on survival and spawning success may be measured for the full diversity of populations under management.

3.i. The Action Agencies, in coordination with the Regional Forum, shall initiate an evaluation of transport:inriver benefit ratios for steelhead marked at and transported from Lower Granite Dam during the 1999 smolt outmigration. If the 1999 decision for the long-term operation of FCRPS projects on the lower Snake River includes some continued reliance on transportation, the Action Agencies shall continue studies of the benefits of transporting both steelhead and chinook from Lower Granite Dam in future years.

The ISAB's recent independent peer review suggested that the use of smolt transportation as a tool to mitigate hydrosystem losses and to support the recovery of listed stocks should be considered experimental in the sense that the benefits of transportation should be continually monitored and reevaluated. At present, marking operations at dams provide the only certain method of obtaining statistically robust numbers of marked wild steelhead and chinook smolts for calculating comparative estimates of the survival of transported and in-river migrants.

<u>Long-Term Operation of the FCRPS</u>

3.j. The Action Agencies, in coordination with the Regional Forum, shall investigate relationships between flow, travel-time, and other related parameters and the survival of juvenile Snake and Upper Columbia River steelhead. The Action Agencies shall submit a report to NMFS stating the findings of these investigations by *[date to be determined]*.

3.k. The Action Agencies, in coordination with the Regional Forum, shall investigate the survival of smolts through all routes of passage through the hydropower system including transportation, spill, juvenile bypass systems, and turbines. These comparisons shall include not only direct survival during the juvenile migration, but also smolt-to-adult return rates of fish with different passage histories. This research will be used to determine the passage route(s) that will result in the lowest rates of direct and indirect mortality for juvenile migrants. The Action Agencies shall submit a report to NMFS stating the findings of these investigations by *[date to be determined]*.

3.l. The Action Agencies, in coordination with the Regional Forum, shall investigate the travel time of wild and hatchery steelhead smolts through the free-flowing Hanford reach of the Columbia River. These studies will provide information on the potential travel time of these fish through pools under drawdown conditions. The Action Agencies shall submit a report to NMFS stating the findings of these investigations by *[date to be determined]*.

BASIS FOR NMFS DETERMINATIONS
CONCERNING THE USE OF A MID-COLUMBIA FLOW TARGET
AS MITIGATION FOR
OPERATION OF THE FEDERAL COLUMBIA RIVER POWER SYSTEM

March 1998

National Marine Fisheries Service
Northwest Region
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Background

Hydro system development has changed both the hydrograph and the migration corridor. Pre-impoundment flows were considerably higher and water velocity at a given flow was much higher due to the smaller cross-sectional area of the river. It is not unreasonable to conclude that historical conditions under which listed steelhead evolved resulted in higher survival than present conditions (Raymond 1988).

The 1995 FCRPS Biological Opinion set flow objectives for spring/summer chinook in the lower Snake and lower Columbia Rivers based on the best information available at that time. However, system operations prescribed in that opinion required reservoirs to be as full as possible (i.e., at the flood control rule curve) by April 20, to facilitate meeting spring and summer flow objectives. This operation appears to result in lower April flows in the mid-Columbia because refilling to flood control elevation reduces discharge during that period. Actual daily average flows at Priest Rapids Dam during April, 1995 (a near-average runoff year in the mid-Columbia, 96 percent, and the first year of implementation of the 1995 Biological Opinion), ranged from 64 to 228 kcfs with a monthly average of 102 kcfs; during the first three weeks flows ranged from 64 to 137 kcfs and were lower than 100 kcfs for 14 days.

Two analyses of the effects of the 1995 FCRPS Biological Opinion operation have been conducted. One shows that April flows in the mid-Columbia at Priest Rapids Dam have been considerably lower since listing of Snake River salmon (Figure 1; FPC 1997). This analysis includes both the effects of the variation in runoff each year and the 1995 Opinion operation. Another analysis is a 50-year model study which compares Hydro system operation under the 1995 Opinion with an operation without flow augmentation for salmon. The analysis shows that flows in the mid-Columbia during the first half of April are generally higher or similar under the 1995 Opinion operation (except in some low flow years when flows are lower under 1995 Opinion operations); flows in the second half of April were shown to be always higher under the 1995 Opinion. However, these higher flows in the second half of April appear to be the result of a modeling priority that drafts reservoirs to meet spring flow objectives at McNary without consideration for the need to refill by June 30 to assist in meeting summer flow objectives in the lower Columbia. This is not representative of operational priorities set out in the 1995 Opinion.

Determination

Based on the best available information, the National Marine Fisheries Service (NMFS) believes that low river flows result in reduced survival of listed juvenile mid-Columbia steelhead and that establishment of flow objectives will help increase juvenile survivals; increased juvenile survivals potentially lead to increased adult returns in the long term. The NMFS recognizes the lack of reach survival information relative to the listed steelhead in the mid-Columbia, but believes that the available data, including those available elsewhere such as in the Snake River, support the designation of a mid-Columbia flow objective for steelhead.

The Action Agencies propose to improve flows in the mid-Columbia River through additional flow augmentation and manage those flows on a weekly basis in-season to maximize fish survival. To provide additional volume during the spring outmigration, and thereby assist in achieving improved flows, the Action Agencies propose to operate the Federal Columbia River Power Systems (FCRPS) in a manner that provides the same confidence of refill, as defined in the 1995 FCRPS Biological Opinion, to flood control elevations by April 10, each year.

The NMFS' goal for operations in the mid-Columbia is to operate the FCRPS in a manner that matches available water to fish movement during the spring and refills reservoirs by June 30. The actual amount and timing of flow augmentation and the degree to which the June 30, refill objective is met will be determined in-season by the TMT. The TMT, in recommending the shaping of flows in the mid-Columbia, will consider the desire to meet a weekly average flow objective of 135 kcfs from April 10, through June 30, the desire to refill by June 30, timing, magnitude and condition of the juvenile migration, water temperature, spill and total dissolved gas levels, adult fish and other requirements for improved survival of listed fish. The dates April 10, through June 30, are for planning purposes (Bickford 1996, Wells Dam hydroacoustic data, 1982 to 95; Smolt Monitoring Program Steelhead Index @ RI, 1991 through 1996, FPC).

The Technical Management Team (TMT) may consider and implement flows lower that the objective during the early part of the steelhead migration when fewer fish are present, particularly in low flow years. Flows greater than the objective may be provided on a weekly basis during key points in the migration while acknowledging that lower flows would then need to occur later in the spring migration as a result of the desire to refill reservoirs by June 30, to provide flow augmentation for summer migrants.

In addition, the Action Agencies propose to continue investigating the implementation of new flood control criteria called Variable Discharge (or VARQ) at Libby and Hungry Horse projects in coordination with the Regional Forum and the State of Montana, sovereign tribes, Northwest Power Planning Council, and other regional interests. Implementation of VARQ has the potential of improving winter reservoir conditions for resident fish and wildlife, and provide higher discharges in the spring for listed species. The investigation will include appropriate studies of local and system flood control, economic impacts, resident fish and wildlife, and proposed and listed species including white sturgeon, bull trout, steelhead, and chinook species. A status report on the progress of the studies will be completed by summer 1998. Prior to implementation, the Action Agencies will complete the appropriate NEPA and ESA documentation and will coordinate with Canada on flood control.

Rationale

Studies conducted within and outside the Columbia Basin have established a that general relationship between increasing fish survival and increasing river flows appears reasonable (Cada et al. 1994). The exact causal mechanisms and the importance of each are not entirely understood but include water velocity, spill at dams, water temperature, predation and timing of seawater entry (ISAB 1996). Further, years with low river flows in the Snake do not correspond with years of good adult returns (Petrosky 1991). Additional research is necessary, particularly for mid-Columbia steelhead.

<u>Evolutionary Considerations</u>

Historical flows and water velocities were much higher than those of today, facilitating rapid migration of smolts to the estuary. Hydropower development has slowed juvenile fish migrations because reservoirs now store water, lowering flows, and water velocities have been reduced. Survival of steelhead under conditions in which they evolved appears to have been much higher than present survivals (Raymond 1988).

<u>Travel Time Considerations</u>

Development of the Hydro system has had the effects of lowering flows and increasing the cross-sectional area of reservoirs. Water particle travel time and the travel time of migrating juveniles have both increased (CBFWA 1991). Travel times of hatchery and wild steelhead between Wells and McNary Dams and Rock Island and McNary Dams have been analyzed by several investigators (FPC 1997; Giorgi et al. 1997; Berggren and Filardo 1993). Results show significant relationships (with varying degrees of predictive capability) between increasing flows and decreasing migrant travel time (Fig. 2, 3, 4).
Travel time-flow relationships in the Snake and mid-Columbia Rivers are similar, i.e., significant relationships with similar shapes show travel time decreasing as flow increases (Figures 2 & 3 vs 5). No information regarding relationships between flow and reach survival is available for the mid-Columbia. In the Snake River, recent PIT-tag information studies by NMFS found a significant positive relationship between flow and reach survival for hatchery steelhead when all years (1994, 1995, 1996) were combined, although the relationship had considerable variation around the estimate of reach survival at a given flow (Smith et al. 1997). No relationship between flow and survival was detected within years. Further analysis is ongoing in an attempt to address the effect of the overlap of similar environmental conditions on successive release groups of marked fish. This uncertainty is being addressed in ongoing research. An analysis of smolt-to-adult return data collected by Idaho Department of Fish and Game (IDFG) from 1964 to 1992 shows increased returns of Snake River wild steelhead with decreasing travel time (Petrosky 1997; Fig. 6). This data set also shows that under the lowest flows steelhead survived at the lowest rate.

A comparison of the rate of travel of hatchery steelhead in the Snake River to the 1995 FCRPS Biological Opinion flow objectives in the Snake (85 to 100 kcfs) shows that juveniles average about 14 and 16 miles per day at 85 and 100 kcfs, respectively (Figure 7). For listed hatchery steelhead in the mid-Columbia to travel at 16 miles per day, a flow of 135 kcfs would be required (FPC data on mid-Columbia hatchery steelhead 1997, Fig. 7).

Further analysis of the FPC (1997) flow/travel time relationship (within season) in the mid-Columbia indicates that groups of wild steelhead released from Rock Island Dam in April show a strong response to increasing flow (FPC 1997; Fig. 8). Travel times of approximately 12 days to McNary Dam at 105 to 120 kcfs are reduced to approximately eight days (33 percent travel time reduction) with an increase in flows to 135 to 140 kcfs (14 to 29 percent increase). Fish released in the first half of May show a decrease in travel time to 6 days with flows up to 175 kcfs (Fig. 9) and fish migrating during the last half of May show a decrease in travel time to four days with flows near 230 to 240 kcfs (Fig. 10). Hatchery steelhead show similar results (Fig. 11, 12, 13).

This response of steelhead to flows during all periods of their migration has been investigated by a modeling effort (Zabel et al. 1996) at the University of Washington by Van Holmes (1997). Holmes found that in the mid-Columbia, steelhead begin their migration with high migration rates, use the current extensively and do not show much seasonal variation in migration rate. In this analysis, reductions in travel time of migrating juvenile steelhead appear to occur with increasing flows across the full migration season.

Past recommendations have suggested 140 kcfs as a minimum flow in the mid-Columbia River between early April and mid-June (CBFWA 1991; WDFW letter to BOR, May 15, 1997). Travel time information for wild steelhead in the mid-Columbia indicates that 135 kcfs is a conservative flow objective; reductions in travel time are apparent at even higher flows (Fig. 2&3).

Temperature Considerations

Other environmental variables in addition to flow affect the travel time of migrating juveniles. Breggren and Filardo (1993) found that temperature and flow explained about equal proportions of the variation in estimated travel time of mid-Columbia hatchery steelhead. The effect of increasing river temperatures was to decrease smolt travel time. Laboratory information suggests that water temperatures in excess of about 54° F for about 20 days may cause steelhead smolts to revert to parr (Chapman et al. 1994). Water temperatures in the mid-Columbia at Rock Island Dam were 53° F in late April in 1989, 1990 and 1993, and temperatures were 54 to 55° F in 1992 (FPC 1994). Reducing the travel time of migrating steelhead smolts by increasing flows would enable more fish to emigrate before water temperatures reach 54° F or higher, reducing residualism.

Smolt-to-Adult Survival Considerations

Smolt-to-adult survival analyses take more factors into account than do juvenile river reach survival estimates. Factors include lower Columbia riverine conditions below Bonneville Dam, estuarine conditions, extent of the Columbia River plume, ocean conditions and adult losses during migration.

Brown (1995) estimated smolt to adult survival rates (SAR) for mid-Columbia hatchery-origin summer steelhead returning to Priest Rapids Dam from 1984 to 1992. A regression of SARs against April 15 to May 15 average flows (Fig. 14) indicates that SARs were less than one percent at flows below 135 kcfs and were always greater than one percent at flows above 135 kcfs. Average SARs at less than 135 kcfs were 0.74 percent; SARs above 135 kcfs averaged 2.1 percent, almost three times higher.

Raymond (1988) estimated the SARs of hatchery and wild steelhead from the mid-Columbia between 1962 and 1984. A regression of SARs against April 15 to May 31 average flows (Fig. 15) indicates that flows above 120 kcfs generally resulted in higher SARs than flows below 120 kcfs; SARs as high as those above 120 kcfs did not occur below 120 kcfs.

Mullan et al. (1992) estimated SARs of Wells hatchery steelhead from 1982 to 1987. A regression of SARs against April 21 to May 31 average flows (Fig. 16) indicates that flows above 140 kcfs resulted in SARs generally three times higher than flows below 140 kcfs.

Public Review Draft **March 18, 1998**

BASIS FOR NMFS DETERMINATIONS CONCERNING THE USE OF JUVENILE FISH TRANSPORTATION AS MITIGATION FOR OPERATION OF THE FEDERAL COLUMBIA RIVER POWER SYSTEM

March 1998

National Marine Fisheries Service
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Background

Transportation has demonstrated benefits for Snake River spring/summer chinook and steelhead and is likely to benefit Snake River fall chinook and sockeye salmon. Accordingly, NMFS decided in the 1995 Biological Opinion (1995 FCRPS Biological Opinion) on Operation of the Federal Columbia River Power System (FCRPS) that it is appropriate to continue to rely on transportation as a major means to mitigate the adverse impacts of the FCRPS projects. At the same time, however, National Marine Fisheries Service (NMFS) recognized the concerns raised about uncertainty in the application of the data to operating decisions, the absolute benefits of transportation, and its ultimate efficacy as a recovery tool. The NMFS agrees that transportation by itself is unlikely to provide sufficient adult returns for recovery of listed Snake River salmon. As a result, the 1995 FCRPS Biological Opinion recommended an improved evaluation of transport and in-river survival and adult return rates to provide better information for use in decisions on long term alternatives. Although results from groups released after 1996 will not be available in the 1999 decision time frame laid out the 1995 FCRPS Biological Opinion, NMFS believes it is appropriate to continue to collect this information in 1998 and beyond. (Other PIT-tag studies such as the hatchery study will also provide valuable information on survival under optimal in-river conditions.)

The NMFS study plan requires measures to keep control fish in river (or return them to the river if they happen to be collected), to estimate their survival to below Bonneville, and to provide the best possible survival conditions for in-river migrants. To accomplish this an interim operation was adopted that involved some reduction of spring transport. Under this operation spring transport from McNary Dam has been eliminated (1994 was the last year of spring transport from McNary, but summer transport from McNary continues). In addition, spring spill is provided at Little Goose and Lower Monumental in years in which flows are expected to exceed 85 kcfs, and at Lower Granite in years in which flows are expected to exceed 100 kcfs. The 1995 FCRPS Biological Opinion also empowered the Technical Management Team (TMT) to make adjustments to keep more fish in-river if evidence is presented that fish would benefit.

The NMFS acknowledges there is a risk that this operation will result in fewer adult returns of chinook and steelhead in the near term than would occur with maximum collection and transport (i.e., through the elimination of spill at the collector projects). However, the 1995 FCRPS Biological Opinion initiated a process to gather and analyze information in anticipation of a long-term decision to minimize risk to the chinook. The ability to make a timely decision on long term alternatives is critical to the no-jeopardy conclusion in that opinion. Therefore, we believe that the near term risk of lower adult returns is justified on the basis of the information to be gained on the performance of in-river migrants under best-possible conditions with the existing dams.

The effect (though not the intent) of the 1995 FCRPS Biological Opinion operation was a spreading of the risk, since it assured that a greater proportion of fish would remain to migrate in river, while also assuring implementation of the best possible survival conditions for in-river migrants. At the time, NMFS estimated that the operation (absent in-season adjustment by the TMT) would result in transport of 74 percent of spring/summer chinook arriving at Lower Granite in years between 85 and 100 kcfs, and 56 percent in years above 100 kcfs. In practice, we have experienced:

	Estimated percent transported		**Average Spring Flow at Lower Granite (kcfs)**
	Hatchery	**Wild**	
1995	58	67	94
1996	46	60	124
1997	43	55	162

(see Graves and Ross 1998, draft report).

Due to large volumes of surplus spill (i.e., in excess of hydraulic capacity or of the demand for power generation) in both 1996 and 1997, a change of NMFS policy of directing spill at collector projects would not have significantly changed these proportions. Further, attempts to reduce or eliminate spill at Lower Granite, Little Goose and Lower Monumental would also have added to dissolved gas problems experienced at other projects in both of those years.

The question that NMFS considered for interim operations in 1998 and beyond was whether listing of Snake River and Upper Columbia River steelhead, or preliminary returns from the 1995 Snake River chinook transport study, should cause a change in the current policy as defined in the 1995 FCRPS Biological Opinion and summarized above. The potential actions resulting from a change in policy would include reduction or elimination of spill at Snake River collector projects (which is now provided only if specified flow triggers are met or exceeded), and resumption of spring transport from McNary Dam.

Due to the controversial nature of the transport decision, and the fact that much of the debate centers on interpretation of the best available scientific information, NMFS and the other sovereigns who participate in the Regional Forum process referred a set of questions concerning that data to the Independent Scientific Advisory Board (ISAB). The ISAB was asked to specifically consider the likelihood that collection and transport in 1998 would result in increased adult returns compared to allowing those same fish to migrate in-river in 1998.

The ISAB response (Williams et al. 1998 -- attached) noted that “[b]arging juvenile stream type chinook (spring/summer) and steelhead should improve survival for some populations of these two types of fish, but it is not known which populations would benefit.” The report also noted a mismatch between the current mixed barge and truck transport program and the available data for barging alone and for trucking alone. In brief, they concluded (among other things) that:

- "Spreading the risk of negative outcomes among alternative routes of hydroelectric passage is advisable..." for a variety of reasons;

- "Hydroelectric system operations need to be conducted to maximize survival for emigrants remaining within the Federal Columbia River Power System, regardless of the transport protocol." (emphasis added); and

- "Trucks should not be used in the transportation program."

NMFS Determination

Snake River: For the Snake River dams NMFS' has determined that spring spill should be continued at all three collector projects, provided that flows exceed the specified triggers. NMFS has further determined that the Lower Granite trigger should be decreased from 100 kcfs to 85 kcfs to be consistent with the trigger at Little Goose and Lower Monumental dams.

McNary: For McNary Dam NMFS has determined that the moratorium on spring collection and transportation from McNary adopted in 1995 should be continued. The NMFS has further determined that future research is needed on transport from McNary Dam, specifically on the response of Upper Columbia River steelhead to transportation. Development and implementation of such research was considered for 1998, but was determined infeasible. At such time as a research plan is approved through the Regional Forum process, limited spring transport from McNary may occur for research purposes.

Transportation of Summer Migrants: No change in operations is proposed for juvenile fish transportation during the summer migration. As before, the transportation collector projects should be operated to maximize collection and transportation (i.e., no voluntary spill except as needed for approved research) during the summer migration. Working with NMFS through the Regional Forum process, however, the Corps should develop and implement measures to reduce the heavy reliance on truck transport for summer migrants.

Rationale

Snake River: The NMFS' rationale for recommending continued spill at the Snake River collector projects is that

(1) The transport/in-river survival evaluation should continue in 1998 and beyond with operations designed to maximize the survival of spring/summer chinook and steelhead migrating in-river. Continued comparison of juvenile survival and adult return rates between fish transported and fish left to migrate in-river will provide information on the ability of transportation to avoid mortalities associated with passage through the FCRPS, and the adequacy of either in-river or transport survival to provide for recovery in the absence of drawdowns. Maintenance of flow and spill conditions that maximize project and reservoir passage survivals for the in-river fish is critical to this evaluation.

(2) A decision to drop conditions necessary for continuation of the study and initiate maximum transport should *not* be based on partial data from a single year (i.e., the preliminary returns from the 1995 study),

(3) A significant proportion of the spring/summer chinook and steelhead populations is expected to be transported under the existing policy. Leaving remaining fish to pass in-river under better flow conditions (i.e., when the Biological Opinion targets are exceeded) is a prudent risk management strategy given even a modest likelihood that fish passed in spill, rather than *either* fish bypassed or fish collected and transported, may survive and return at comparable or higher rates.

The NMFS rationale for changing the spill trigger at Lower Granite Dam from 100 kcfs to 85 kcfs is that the resulting operation will provide more consistent transport operations throughout the Snake River, and achieve approximately the same or greater proportion of fish transported as was expected under the 1995 FCRPS Biological Opinion. There is no biological basis for applying one trigger at Lower Granite and a different trigger at Little Goose and Lower Monumental dams. The trigger at Lower Granite was set higher in the 1995 FCRPS Biological Opinion simply to increase the proportion of fish transported and thereby err on the side of more fish transported. The installation of extended length screens at Lower Granite and Little Goose since 1995 has since increased the proportion of fish transported under all conditions. As a result, NMFS has determined that the additional transport from Lower Granite under more favorable flow conditions is no longer necessary.

The Fish Passage Center (FPC) recently estimated the proportion of Snake River fish that would be expected to be transported under this operation (FPC memo dated January 29, 1998). Their estimates ranged from 54 to 68 percent for hatchery spring/summer chinook, 62 to 75 percent for wild chinook, and 63 to 77 percent for wild and hatchery steelhead combined. By comparison, the 1995 FCRPS Biological Opinion estimated that 56 to 74 percent of chinook (hatchery and wild were not differentiated) would be collected and transported under that operation.

McNary: NMFS rationale for deciding *not* to resume spring transport operations at McNary at this time stems from concerns identified in the review of adult return information from fish PIT-tagged in the Snake River in 1994 and subsequently transported from McNary Dam (see attached science summary). These data suggest that there may be a previously undetected problem with fish collected at McNary Dam in the new facility that became operational that year. The problem may not be limited to transported fish (i.e., it may affect all fish entering the bypass), but until this question can be resolved NMFS will recommend full spill at McNary Dam (i.e., up to the dissolved gas limit). The NMFS is also concerned with the lack of any recent information on transport from McNary Dam. In view of significant improvements in passage downstream of McNary, and the higher proportion of Snake River fish already being barged without additional transport from McNary, NMFS believes it prudent to approach any resumption of spring transport from McNary as a research experiment focused on the response of fish originating in the Columbia River above the confluence with the Snake River.

Transportation of Summer Migrants: Results of evaluations of summer migrating fall chinook juveniles from McNary Dam all showed positive relationships (see attached Summary of Science Related to Juvenile Fish Transportation). While the ISAB report did not differentiate between spring and summer migrating fish, the NMFS believes that the results of these earlier evaluations, taken together with in-river survival studies which suggest a high mortality rate for summer migrants, especially under conditions of low flow and high temperature experienced toward the end of the migration, support a continued emphasis on maximum transport of summer migrants.

With respect to the use of trucking, NMFS was surprised by the strength of the ISAB recommendation and is still reviewing the information that was the basis of this conclusion. However, based solely on the high proportion of transported subyearling chinook that are moved by trucks (average 92 percent, 1992 through 1996), NMFS shares the ISAB concern. As a result, NMFS intends to continue to work with the ISAB and others to evaluate the potential for reduced risk through greater use of barging. Meanwhile, NMFS will also be working with the Corps and others through the Regional Forum to seek means of extending the use of barges, and thereby reduce the heavy reliance on trucking.

SUMMARY OF SCIENCE RELATED TO JUVENILE FISH TRANSPORTATION

Introduction

Juvenile fish transportation has been repeatedly evaluated. Since the late 1960s, numerous studies have been conducted using chinook and steelhead smolts. The vast majority of studies show that transported smolts return as adults at a higher rate than in-river control fish similarly collected and marked, but allowed to continue their migration in-river. These data have been peer-reviewed by independent scientists on several occasions. Nevertheless, controversy stemming at least in part from uncertainty over the application of these results to mitigation decisions abounds.

In addition to the transport/in-river comparison studies, various researchers have also evaluated and measured smolt performance, stress, behavior, mortality, disease transmission, and behavior. The results of all these studies have been used to help manage the juvenile fish transportation program.

Pertinent findings to date include:

- Transportation helps reduce the number of juvenile salmonids killed in the existing hydropower system, and thereby increases the number of adults returning to upriver dams and hatcheries.

- The conditions experienced by groups of study fish migrating in the river are largely determined by power system operations.

- Nearly all information concerning the impact of transportation on migrating smolt physiology and performance has been collected from hatchery fish. No clear trends in swimming performance have been observed in chinook salmon—either before or after barging.

- In early season trials, elevated levels of blood plasma cortisol (a physiological indicator of stress) in barged chinook salmon and steelhead were largely eliminated during transport. However, at the peak of the migration, plasma cortisol levels remained elevated throughout the collection and transportation process.

- Video monitoring of fish behavior in raceways (and in barges during transport) show startle responses of undetermined cause. Classic aggressive behaviors were rarely observed.

- Straying rates for transported fish are very small (1% to 3%), apparently no greater than natural rates

- There are, thus far, no conclusive research results regarding transportation's ability to improve returns to the spawning grounds or to provide sufficient adult return rates to provide for the recovery of upriver runs.

- There appears to be a consistent (but small) delay during the upstream migration of some transported steelhead. This apparent difference in run-timing, if it is real, does not appear to affect the steelhead's ability to return to the hatcheries in time to spawn successfully.

- No precise data has been collected on juvenile mortality, either during or following transportation.

- Research results and routine observations do not indicate large-scale predation on smolts immediately following their release from the barges.

- Live box studies have suggested that, under certain conditions, uninfected salmonid smolts can become infected with *R. salmoninarum* (presumably shed from infected smolts) during in-river migration or transportation.

Discussions of these and other research findings follow.

Transportation Evaluations

The NMFS research on transportation has shown that collecting fish at upstream dams and transporting them to below Bonneville Dam can reduce juvenile salmonid mortality in the existing FCRPS relative to a control group also collected and marked at the dam, and increase the number of adults returning to upriver dams and hatcheries.

In the various studies, the survival of transported fish (determined by observations of adult returns at dams) is compared to the survival of control fish (intended to represent in-river migrants) and expressed as a transport-to-control (T/C) ratio. This ratio is based on results pooled from individual mark groups; it compares the percent of transported juvenile fish (test fish) that return as adults to the percent returning from juvenile fish that were allowed to migrate in-river, or to those from juvenile fish that were transported a short distance below the marking site and then migrated in-river (control fish).

The conditions experienced by fish migrating in the river are largely determined by power system operations, though nature still plays a role. Forced spill, when available, provides an alternative to passage through the powerhouse. Most studies have collected transport-to-control information during “below average” to “average” runoff years. Thus, there is concern that the reported transportation survival percentages may not be representative of survival during “above average” runoff years (such as 1997). Based on long term records of runoff volume, 1986 and 1995 were “average” water years. Transport studies those years indicate positive results for transported fish (the 1995 study results are preliminary but are not expected to change). When available, results from the 1996 evaluation will represent migratory conditions during an “above average” water year.

There is concern within the fisheries community that control groups of fish from the NMFS’ studies may not be representative of the run-at-large, since these fish are collected and marked after having passed through a juvenile bypass system. This so called “handling” is the subject of continued debate. On the other hand, in-river migrants are expected to pass through all available passage routes (i.e., turbines, spillways, bypass systems, etc.)

Management options for not collecting and marking fish at dams are presently limited to evaluating transportation of hatchery fish. Such studies do not provide fishery managers with data on the survival of wild stocks. Ideally, sufficient numbers of wild fish could be marked far upstream of the dams so that their origin would be known and it would be possible to evaluate homing to individual hatcheries and natal streams. Adult PIT-tag detection facilities must be developed for homing studies to occur.

Survival to Adult

1. Yearling Chinook

a. Snake River Studies

Over the course of 24 studies at Snake River dams from 1968 through 1980, T/C ratios have ranged between 0.7 to one and 18.1 to one, with three of the studies reporting T/C ratios below parity (Ebel et al. 1973; Ebel 1980; Park 1985; Slatick et al. 1975). In ten of the tests (42 percent), significantly more transported fish than control fish were recovered as adults, indicating higher survival for the transported groups. In only one test were significantly more control fish recovered than transported fish. In 13 tests (54 percent), adult recoveries were too few to identify statistical differences between returns of transported and control fish (Matthews 1992).

Additionally, a 3-year study of Snake River spring/summer chinook salmon (and steelhead) juveniles transported by barge from Lower Granite Dam was to begin in 1986. However, low flow conditions in 1987 and 1988 precluded studies in those years. At the time, the fishery management agencies were primarily interested in evaluating transport in average- to high-water years because almost everyone believed transportation was better than in-river migration during low water years. Subsequently, only two years of the planned study were completed—1986 and 1989. Results of the 1986 research indicated a T/C ratio of 1.6 to one, with a 95 percent confidence interval (CI) between 1.01 and 2.47 (Matthews et al. 1992). Studies in 1989 indicated a T/C ratio of 2.4 to one, with a 95 percent CI between 1.4 and 4.3.

In 1995 and 1996, spring/summer chinook salmon smolts with passive integrated transponder tags (PIT-tags) were used to evaluate transportation vs. in-river migration from Lower Granite Dam. However, unlike most previous studies, the in-river fish were released directly into the tailrace of the dam where they were collected and marked, instead of the usual course of transporting and releasing them below Little Goose Dam (the next dam downstream). Fin clips were used to separately record the hatchery and wild fish in both the test and control groups during tagging. Preliminary results from the 1995 evaluation show that 59 1-ocean-age and 702 2-ocean-age fish (604 hatchery and 98 wild) were recovered as returning adults at Lower Granite Dam. For hatchery fish, the preliminary T/C ratio is 2.0 to one, with a 95 percent CI between 1.7 and 2.4; for wild fish, the preliminary T/C ratio is 2.4 to one, with a 95 percent CI between 1.6 and 3.8. Results for the 1995 study year will be complete when the 3-ocean-age fish return in spring and summer of 1998. For the 1996 study year, preliminary results show that eight 1-ocean-age fish (seven hatchery and one wild) were recovered at Lower Granite Dam. Six of the fish were transported as juveniles and two were released as in river controls. Results for the 1996 study year will not be complete until the summer of 1999 (G. Matthews, pers. comm.).

While the majority of the juvenile salmonids presently being transported are of hatchery origin, Snake River transport evaluation studies conducted between 1968 and 1973 used predominantly wild spring/summer chinook salmon. The results of those studies show significantly more adults returning from the transported test groups than the non-transported (Ebel et al. 1973; Ebel 1980; Slatick et al. 1975). The T/C ratios for adults returning to the dams during those years ranged from 1.1 to one to 18.1 to one; similar T/C ratios were documented at the hatcheries and spawning grounds (Ebel et al. 1973; Ebel 1980; Slatick et al. 1975).

Conclusion: Transportation is an effective means of helping to reduce the number of juvenile chinook killed in the existing hydropower system, and to thereby increase the number of adults returning to upriver dams and hatcheries.

b. Lower Columbia River Studies

Yearling chinook. A 3-year series of studies of transportation from McNary Dam on the lower Columbia River was conducted in the late 1980s. Studies in 1987 suggest there is a positive association between transport and survival of spring chinook salmon, this is based on a pooled T/C of 1.6 to one (95 percent CI, 1.18 to 2.25). The T/C ratios for all individual mark groups were positive; however, the lower limit of the 95 percent CIs for three of the five groups was less than one (Achord et al. 1992). Transportation studies using spring chinook salmon at McNary Dam in 1988 resulted in a T/C ratio of 1.6 to one, with a 95 percent CI between 1.0 and 2.6.

Subyearling Chinook. Transportation evaluations of fall chinook subyearlings migrating during the summer have shown positive benefits. Adult returns of fall chinook salmon released from McNary Dam in 1986 as juvenile transport and control groups indicate a T/C ratio of 2.8 to one, with a 95 percent CI between 1.4 and 5.6 (Harmon et al. 1993). Studies at McNary Dam in 1987 also show a positive association between transportation and subyearling chinook salmon survival (T/C of 3.5 to 1; 95 percent CI 1.7 - 7.1) (Harmon et al. 1995). The NMFS initiated a new 3-year subyearling chinook transport evaluation from McNary Dam in 1995. Marking occurred in 1995 and 1996 using ad-clip/coded-wire tagged groups. Control groups were released to the tailrace through the bypass outfall of the new juvenile facility, whereas transported groups were trucked or barged. The third year of marking has been postponed pending the availability of funds. Study results will be based on adult recoveries in ensuing years. Generally it takes six to seven years to be certain that all tags are in from the year in which the juveniles were marked.

Conclusions: The benefits of transporting yearling chinook from McNary Dam under existing migratory conditions are unknown. Previous studies evaluated facilities and migratory conditions that are no longer representative. A new juvenile facility was completed in 1994, therefore, additional studies are desirable. Results of past studies of subyearling chinook all showed positive relationships. Results of more recent studies will not be available for some time.

2. Steelhead

a. Snake River Studies

From 1969 through 1980, 22 separate juvenile steelhead transportation studies were conducted at dams on the Snake and Columbia Rivers. Of the 22 studies, 17 were conducted at various Snake River dams and five were conducted at McNary Dam on the Columbia River. Transportation methods using both trucks and barges were tested. In all of the Snake River studies, steelhead that were transported as juveniles had significantly higher adult return rates than did those that migrated in-river. The 17 Snake River studies showed T/C ratios ranging from 1.3 to one to 17.5 to one (Ebel et al. 1973; Slatick et al. 1975; Ebel 1980; Park 1985; Matthews 1992).

Studies conducted in 1986 and 1989 also demonstrated positive transport benefits. Steelhead transported by barge from Lower Granite Dam in 1986 showed a T/C ratio of 2.0 to one, with a

95 percent CI between 1.4 and 2.7 (Matthews et al. 1992). Results from a similar study conducted in 1989 showed a T/C ratio of 2.1 to one, with a 95 percent CI between 1.3 and 3.5 (Harmon et al. 1995). These results confirm the earlier work with steelhead and strongly indicate that more adult fish return from juveniles transported to below Bonneville Dam than do from juveniles allowed to migrate through the hydropower system.

Steelhead Adult Return Rates. During studies conducted at Lower Granite Dam from 1975 through 1980, adult return rates of transported juvenile steelhead were consistently between 2.5 percent and 4.7 percent for the composite hatchery/wild population (Park 1985). During that period, Raymond (1988) estimated wild fish annually made up roughly 30 percent to 70 percent of the smolt population. Similarly, from 1984 through 1988, adult return rates of transported steelhead were consistently between 2.6 percent and 3.2 percent for the composite population. Since 1986, all hatchery steelhead juveniles have been identifiable by an adipose fin clip—allowing adult return rates and T/C ratios to be independently estimated for hatchery and wild fish. Adult return rates of wild steelhead juveniles transported in 1986, 1987, and 1989 were 4.5 percent, 2.7 percent, and 0.8 percent, respectively (G. Matthews, NMFS, personal communication).

In 1994, the Independent Peer Review Team (IPRT) completed a review of the data available on the benefits of transporting juvenile fish (Mundy et al. 1994). The IPRT findings and conclusions indicated that "the kinds of Snake River salmon for which transportation is likely to improve relative survival to the point of transportation are the steelhead, and to a lesser degree, the yearling-migrant stream-type chinook salmon designated as "spring/summer chinook" salmon by NMFS."

Conclusion: Transportation is an effective means of helping to reduce the number of juvenile steelhead killed in the existing hydropower system, and to thereby increase the number of adults returning to upriver dams and hatcheries.

b. Lower Columbia River Studies

In all but one of five studies conducted at McNary Dam between 1978 through 1980 (three truck tests and two barge tests), significantly more adults were recovered from groups that were transported than from groups released as in-river control fish. In one study, a trucked group returned at only a slightly higher rate than the paired in-river control (the difference was not significant). T/C ratios ranged from 1.3 to one to 1.3 to one (Park et al. 1984). The two barging studies (1979 and 1980) demonstrated statistically significant differences between transported and control groups in both years (Park 1985). The 95 percent CIs were not developed for data analyses of the studies conducted prior to 1986.

Conclusions: The benefits of transporting steelhead from McNary under existing migratory conditions are unknown. Additional studies are needed but technological problems (i.e., adult

PIT-tag detection capability in fishways at several dams) must be overcome. Past studies showed positive benefits. However, a new juvenile facility, with much improved bypass outfall conditions, was completed in 1994. Preliminary results of PIT-tag data analysis suggest that fish transported from McNary in 1994 returned at a lower rate than fish transported from other dams.

3. Sockeye

The only data available on sockeye salmon T/C ratios are results from studies conducted on juveniles transported by truck and barge from Priest Rapids Dam between 1984 and 1988 (Carlson and Matthews 1990; Carlson and Matthews 1991). Final statistical analyses of transport benefits of these studies have not been reported and it is not known when the final report will be completed. However, the reported preliminary T/C ratios vary widely, and range from 0.55 to one to 4.23 to one.

Conclusion: The benefits of transporting sockeye from Snake River dams or from McNary Dam under present conditions are unknown.

1994 and 1995 PIT-Tag Data Analyses

The NMFS has conducted research studies over the past 25+ years to evaluate whether transportation of juvenile fish from upper Snake River dams increased adult fish returns compared to returns from juvenile fish that migrated through the hydropower system. The general methodology for all of the studies was to collect fish at a dam and mark two groups - one for transportation and one for migration through the hydropower system. Fish for transportation were placed into either trucks or barges, transported below Bonneville Dam and released. Fish marked to evaluate migration through the hydropower system were generally trucked and released a few km upstream of the dam where they were marked or trucked downstream below Little Goose Dam and released. In the late 1970s some fish were released directly into the tailrace of lower Granite Dam, but an unknown number were likely subsequently collected and transported from Little Goose Dam. Adult returns from studies conducted between 1968 and 1989 all indicated a higher adult return rate from fish transported than from those that migrated through the hydropower system. Nonetheless, the overall adult return rate of salmon was, in nearly all cases, much lower than historic rates of return prior to completion of the Snake River dams and John Day Dam on the Columbia River. In spite of the higher return rates of transported fish, many in the fisheries community suggested that there was something wrong with transportation because of low adult returns. This prompted some recent reviews of the transportation research. The reviews generally concluded that fish released as controls in the earlier studies were not “true” controls because they were transported to release sites.

To address this issue, NMFS began new studies in 1995 to evaluate transportation of spring/summer chinook salmon from Lower Granite Dam. All fish in the new studies were individually marked with PIT-tags. Daily, a group of fish were loaded into barges for transportation. Another group was released directly back to the tailrace of Lower Granite Dam. The development of slide-gate systems at collection facilities downstream of Lower Granite Dam allowed bypass of most PIT-tagged fish to the tailraces of dams so that river migrants were not transported. Any fish designated for the river migrant groups that were inadvertently transported were identifiable and removed from the study data base. To date, 1- and 2-ocean adult fish have returned from the 1995 study. In 1998, 3-ocean fish will return. We estimate that 75 to 80 percent of the hatchery fish and 20 to 30 percent of the wild fish have returned thus far. As previously reported (memorandum of 1 August 97 from Michael H. Schiewe to William Stelle), the adult return rate of PIT-tagged, transported spring/summer chinook salmon was approximately twice as high as the PIT-tagged fish released into the tailrace of Lower Granite Dam that migrated through the hydropower system. Although based on incomplete data (and hence preliminary), the differences were statistically significant and are consistent with ratios of returns from previous studies in which the research fish were all collected and marked at the same dam.

In late 1997, NMFS and Idaho Fish and Game biologists began examination of wild and hatchery steelhead and spring/summer chinook salmon returns from fish that were PIT-tagged in 1993 (PIT-tagged as parr, but migrated in 1994), 1994, or 1995 and released at sites *upstream* of Lower Granite Dam. PIT-tagged fish that migrated downstream in 1994 and 1995 and were collected in the bypass systems at Lower Granite, Little Goose, Lower Monumental, and/or McNary Dams and were detected by PIT-tag electronic detection systems were placed into different categories depending on their detection histories at the four dams. At each dam, fish were either detected and transported, detected and bypassed back to the river, or were not detected (presumably passed the dams via spill or turbines). A small number of fish were detected but their fate was unknown. The two categories given the most attention recently are: 1) fish transported at Lower Granite and Little Goose Dams and 2) fish that passed through the four dams undetected. The number of transported fish was known, but the number of fish that passed through the system but were not detected required an estimate.

Conditions varied between the two migration years. In 1994 there was no spill and moderate flows until May 10th and then high flows with high spill. In 1995 there were moderate flows throughout the migration period and spill was provided at all dams downstream of Lower Granite Dam throughout the migration period. Adult returns from the 1994 migration and 1995 juvenile steelhead migration are complete, while 1995 spring/summer chinook salmon migration adult returns are incomplete.

Unlike the 1995 NMFS transport study at Lower Granite Dam, PIT-tagged fish released above Lower Granite Dam were tagged for many reasons, at many locations, and may not represent the population of untagged fish. Further, fish from these groups may not have arrived at Lower Granite Dam or migrated through the hydropower system similar to the general population. With relatively small numbers of juvenile fish and low numbers of adult returns in the different detection history categories, they may only represent small segments of general population. Additionally, numbers of fish in different detection history categories were not set to accurately ensure statistical power to detect true differences in adult returns.

We have not yet conducted statistical analyses comparing return rates between different detection history categories. Such analyses require variance estimates that are not yet developed. Variance estimation is complicated because variability is introduced at several steps in the process of estimating return rates, and the variance components interact in mathematically complex ways. Statistical inference for comparisons involving data from the studies of PIT-tagged fish released above Lower Granite Dam will be made when appropriate variance estimates are determined. In many cases, insufficient statistical power will exist to detect true differences between groups because of relatively small adult return numbers and/or imprecise return rate estimates. However, the following *patterns* were observed in these data:

1. Fish detected at multiple dams returned at a lower rate than fish transported or detected at only one dam.

2. In most cases, fish transported from McNary Dam in 1994 returned at a lower rate than fish transported from other dams.

3. From the 1994 juvenile migration, wild and hatchery steelhead and wild spring/summer chinook salmon transported from Lower Granite and Little Goose Dams combined returned at higher rates than those that passed through the hydropower system undetected under existing conditions. However, the reverse occurred for hatchery spring/summer chinook salmon in 1994 and hatchery steelhead in 1995 (no adult returns for wild steelhead for either group in 1995).

4. In both 1994 and 1995, approximately 5 to 15 % of the estimated PIT-tagged fish in the population migrated undetected to below McNary Dam.

No other patterns were apparent for fish with complete returns. Since an additional 20 to 80 percent of the hatchery and wild spring/summer chinook salmon from the 1995 migration are expected to return in 1998, complete analyses for these stocks will not occur until mid-August 1998. The above patterns are potentially important considerations in determining future operations and configuration of the hydropower system. Accordingly, we intend to aggressively pursue collection and analysis of these and future data to provide rigorous biological and statistical rationales for future management decisions.

Behavior

Impaired swimming performance can reasonably be expected to reduce juvenile survival following their release. Chinook salmon swimming performance has been evaluated before and after barging and no clear trends have been observed (Schreck and Congleton 1994).

Fish behavior has been examined (using underwater video) in raceways and in barges during transport. Most of the observed interactions were startle responses of undetermined cause. Classic aggressive behaviors were rarely observed. The behavior of yearling chinook immediately after their release was also monitored using radiotelemetry. The information provides an estimate of the downstream migration speed for each radio-tagged fish, gives the minimum number of tagged fish successfully migrating through the prescribed release area, and allows estimates of their migration time and rate of survival from the smolts' release below Bonneville Dam to their arrival at the estuary. At release, most of the radio-tagged fish released from barges moved downstream at a rate of one to two miles per hour. This rate of movement is comparable to that observed in previous study years. The majority of the tagged fish reached the estuary in 36 to 72 hours after release (Schreck and Congleton 1994). Radio-tagging studies of migration speed have found that run-of-river yearling hatchery chinook migrate faster than do barged hatchery chinook released at the same time and under the same flow conditions. Run-of-river fish also appear to travel in tighter groups than do barged fish. The authors speculate that the observed difference in travel time may be the result of some difference in fish condition. However, the barged chinook groups were known to be Snake River stocks, whereas, the run-of-river chinook collected and tagged at Bonneville were not. The authors also speculate that an insufficient degree of smoltification, or osmoregulatory or other disturbances associated with transportation, may potentially delay ocean entry (Schreck et al. 1997a).

Conclusions: Nearly all information concerning the impact of transportation on migrating smolt physiology and performance has been collected from hatchery fish. No clear trends in swimming performance have been observed in chinook salmon—either before or after barging.
Video monitoring of fish behavior in raceways (and in barges during transport) show startle responses of undetermined cause. Classic aggressive behaviors were rarely observed.
Research results and routine observations do not indicate large-scale predation on smolts immediately following their release from the barges.

Straying/Homing Impairment

According to Quinn, "straying is the migration of mature individuals to spawn in a stream other than the one where they originated. From the standpoint of orientation, a salmon strays if it ascends a non-natal river and does not subsequently make its way to its natal river. If a fish enters a hatchery, it is seldom given the chance to retreat, so there is some question as to whether 'strays' entering hatcheries would have eventually left." Further, "estimates of straying vary greatly between hatcheries and rivers, so general statements on straying proportions have minimal biological significance" (Quinn 1993).

1. Natural Straying Rates

A study by Shapovalov and Taft at Scott and Waddell Creeks (California) found that steelhead strayed between the creeks at rates of 2 percent and 3 percent, respectively. Another study by McIsaac on the homing of wild, wild/hatchery (reared 10 weeks in a hatchery), and hatchery fall chinook in the Lewis River (Washington) found that the wild chinook strayed at a rate of 3.2 percent. Wild salmon have also been observed to stray into hatcheries. Nicholas and Van Dyke estimated that 64.7 percent of the wild coho salmon returning to the Yaquina River watershed (Oregon) in 1981 entered the Oregon Aqua-Foods hatchery (reported by Quinn, 1993).

2. Straying Rates of Transported Salmon

There is no direct evidence to show that wild and hatchery salmon, transported from Snake River dams as juveniles, wander into rivers at higher rates than they would naturally. Reported rates of straying among transported fish are very small (1 to 3 percent). Marked steelhead from transport study groups (control and transported) have been reported in the Deschutes River (Oregon). Specifically, during the trucked-fish transport studies conducted during 1970 through 1973 at Little Goose Dam, the T/C ratios were the same for adult steelhead recovered from the Deschutes River and for those captured at Little Goose. This indicate that the trucked fish were not straying into the Deschutes at any rate higher than did fish that migrated in the river as smolts. Further, in studies conducted between 1975 and 1980, 11 spring/summer chinook (0.9 percent of the run), and 16 steelhead adults (0.2 percent of the run) were identified as "strays." All were transported from Lower Granite or Little Goose Dams. Among the steelhead, 11 of the 16 were released in 1976 (before barge transport began). All of the chinook were observed in the Deschutes River (Oregon), whereas, the steelhead were observed at Wells Hatchery (9), the Deschutes River (3), Big Creek Hatchery (1), Chelan Hatchery (1), and the Yakima Hatchery (1). Ebel concluded, and Park agreed, that straying has a minimal impact on the adults' ability to return to expected spawning areas (Corps 1985).

In analyzing steelhead returns, Park determined that transported fish exhibited a consistent but small delay during their upstream migration. The number of transported fish returning in the spring of each year was higher than that number among the controls (see below) implying a delay for the transported fish. About 10 percent of the transported fish delayed during migration. Further analysis indicated that transporting steelhead from the Clearwater River causes a minor delay in their upstream passage (Corps 1985). Matthews (1992) postulated that the delay Park noted was more likely due to a slightly later river entry for adults returning from groups that were transported as juveniles. This was not observed in the A-run steelhead because most were above the dams when their migrations ceased the previous fall; therefore, they would not have been observed at the dams during the spring migration. Because B-run steelhead migrate later than the A-run, the late segment of that population would over-winter in the reservoirs below the dams and could thus be observed the following spring when they continue their migration. This may have been occurring in the A-run as well, but it simply was not observed. In any event, the slight difference in run timing, if it is real, does not appear to affect the steelhead's ability to return to the hatcheries in time to spawn successfully.

The Independent Peer Review Team (IPRT) findings indicate that, due to the experimental design of the studies, Snake River transportation research results to date are not conclusive regarding the ability of transportation to improve returns to the spawning grounds (Mundy et al. 1994). Limited evidence exists, however, based on adult returns at hatcheries. For transportation studies conducted from Lower Granite on steelhead in 1986 and 1989, the T/C ratios for adult returns recovered at hatcheries above Lower Granite Dam were not different in either year than the T/C ratios measured on adult fish at the dam (Matthews et al. 1992, Harmon et al. 1993).

3. Mid-Columbia Studies

The transportation of spring chinook and sockeye salmon juveniles from Wanapum and Priest Rapids Dams was researched from 1984 through 1988. These studies indicate that jaw-tagged sockeye adults (that were transported as smolts) took longer to reach Priest Rapids Dam than did the control groups in two of five years; chinook adults took longer in one of three years. Jaw-tagged sockeye and chinook adults from transported groups fell back below Bonneville Dam more often than did control group adults, and sockeye transported solely by truck fell back more often than did sockeye transported by barge. These results suggest that transportation impairs homing (expressed as migration delay) in adult sockeye between Bonneville and Priest Rapids Dams. The studies did not, however, indicate that sockeye or chinook homing was impaired between Priest Rapids Dam and the spawning areas. Coded-wire tag (CWT) recoveries from sockeye suggest straying occurred in four truck-transported and four control fish from the 1985 tests. Other CWT recoveries include two trucked- and one trucked-and-barged sockeye from the 1987 tests. The authors did not view those eleven strays as excessive—though straying likely exceeded the number estimated from CWT records. For example, two jaw-tagged and truck-transported sockeye adults from the 1985 study were found in the Lewis River. For chinook salmon that were transported by truck, four strayed in 1984 and eight strayed in 1985. However, all of the 12 had passed hatchery weirs and therefore could not return downstream. According to the authors, the fact that all but one of the 12 were from transported groups may indicate more wandering by chinook salmon trucked as juveniles. The authors cautioned that homing results observed in transported and control sockeye and chinook salmon have relevance primarily for the conditions that were created for their study, and may or may not have relevance elsewhere for trucked or trucked-and-barged sockeye, or to other species or fish barged from collector dams (Chapman et al. 1997).

4. Recent Straying Concerns

Last fall, concerns were raised over a reported increase in out-of-basin hatchery steelhead reported in the Deschutes River (Oregon) late in the season. Deschutes Basin hatchery steelhead receive distinctive marks so non-native steelhead are identifiable at hatcheries and weirs. Some suggest that, based on the timing of these observations, the majority of these fish remain to spawn in the Deschutes. Since spawning between native and out-of-basin stocks can impact genetic viability, there is valid cause for alarm. Observations of non-Deschutes hatchery steelhead at Sherars' Falls and at upstream hatcheries have increased simultaneously with increased numbers of steelhead transported from the Snake River. Olsen et al. (1991) attempted to correlate an increase in adult hatchery steelhead straying into the Deschutes River with an increase in the number of steelhead juveniles being transported from the dams. There is no direct evidence, however, that this is occurring, nor is there any to show that this behavior may be related to juvenile fish transportation.

Research that was conducted from 1992 to 1994 comparing the survival of steelhead transported to Tongue Point, Oregon with that of steelhead transported to the traditional release site below Bonneville Dam provides some information regarding the straying of transported fish into the Deschutes River (Oregon). Overall returns through 1996 (preliminary results), show that 573 steelhead returned to Lower Granite Dam, nine were observed in the Deschutes. This is therefore, a straying rate of 1.6 percent, well within expected natural straying rates. There were no marked, in-river transport control groups for the aforementioned studies. Information from the 1986 and 1989 transportation evaluations at Lower Granite Dam showed that one out of 500 returning adult steelhead (0.2 percent) was observed in the Deschutes River. Pooling all the available information from the 1986, 1989, and 1992 through 1994 studies shows that ten out of 1073 (0.9 percent) transported steelhead that returned as adults strayed into the Deschutes River (G. Matthews, NMFS, personal communication, and Marsh et al. 1997).

Conclusions: Reported straying rates for transported fish are very small (1 to 3 percent), apparently no greater than natural rates. There appears to be a consistent (but small) delay during the upstream migration of some transported steelhead. This apparent difference in run-timing, if it is real, does not appear to affect the steelhead's ability to return to the hatcheries in time to spawn successfully.

There are, thus far, no conclusive research results regarding transportation's ability to improve returns to the spawning grounds or to provide sufficient adult return rates to provide for the recovery of upriver runs.

Mortality

There are a number of ways fish can die during the collection, holding/loading, transport, and release procedures. Some of these losses can be directly observed in various parts of the juvenile collection system (i.e., gatewells, wet separators, raceway screens, barge compartments, etc.). Other sources of mortality cannot be observed directly (e.g., impingement on screens and potential predation in raceways and during transport). Mortality following release, which may be related to the transportation experience, is not observable but may occur, for example, through increased susceptibility to predation or disease. Overall collection facility mortality has been observed to range from 0.1 to 8.9 percent, depending on the individual collection facility, the species, and its life stage (Corps 1997).

There are no precise data on juvenile mortality during transportation. Data from radio-tagged chinook released below Bonneville provide some information on immediate survival following release from barges. The Corps estimates that average seasonal direct mortality (observable mortality before and during transport and at release) for collection and transportation combined is less than two percent (Corps 1993). The PATH group also assumes a 0.98 transportation survival (PATH, in preparation). Stress, injury, and disease transmission are potential causes of transport-related mortality. Larger salmonids may prey upon injured, moribund, or smaller salmonids during transportation. However, observations (using video cameras) have rarely shown aggressive behavior or dead fish on the bottom of barge compartments during release. Collection facilities and operational procedures that may contribute to mortality continue to be researched.

Studies conducted from 1992 through 1996 showed no evidence of large-scale predation on smolts immediately following their release from the barges (Schreck et al. 1993, 1994, 1996, 1997a, Schreck et al. unpublished reports). Using fixed and mobile radio tracking methods, the studies have evaluated the behavior, migration speed, and the routes taken by radio-tagged Snake River yearling chinook during and after their release from transportation barges. The studies also afford a minimum estimate of survival to the lower Columbia estuary. More recent efforts have compared the behavior of barged chinook with that of run-of-river chinook collected at Bonneville Dam. In 1996, 79 to 92 percent of the radio-tagged, barged yearling chinook, and 77 to 97 percent of the run-of-river chinook yearlings successfully reached the lower Columbia River estuary. In the 1997 studies, 74 to 97 percent of the radio-tagged chinook survived to near the estuary (Schreck et al. 1997a). The release date made no difference in the proportion of barged yearling chinook reaching the estuary (P=0.60, Chi-square test), nor was there any statistically significant difference between the barged and run-of-river yearling chinook groups (P=0.34, Chi-square test, release dates pooled). In the 1996 tests, fish condition (as reflected by level of descaling) did not appear to affect the survival of radio-tagged chinook. There was no difference between individuals with greater than 10 percent descaling and those with less than 10 percent descaling in either the proportion of fish reaching the estuary or in the rate of mortality within the estuary (Schreck et al. 1997a).

Preliminary data (2-ocean returns) regarding the survival of yearling chinook classified as "descaled" during marking at Lower Granite Dam are available in the NMFS 1995 transport vs. in-river survival study. The reported 24-hour delayed mortality (24-h DM) of the study fish was 1.6 percent. At the time of tagging, four percent of the juvenile chinook were recorded as being descaled. Twenty percent of the observed 1.6 percent 24-h DM were listed as "descaled" at tagging. Of 703 2-ocean adults returning in 1997, five percent were listed as descaled at the time of tagging. These data suggest that descaling may affect short-term survival, but may not be a factor in overall survival to adult return (personal communication, G. Matthews, NMFS).

Mortality of intentionally descaled chinook salmon and steelhead held at the Lower Granite juvenile facility did not differ significantly from mortality observed in the control groups. Of the fish that died, in both the descaled and the control groups, 75 percent of the chinook and 44 percent of the steelhead developed fungal infections prior to death. These fungal infections normally appeared on the fins rather than on the descaled areas or elsewhere on the body (Congleton et al. 1997).

Conclusion: There are no precise data on juvenile mortality during transportation. There is no evidence of large-scale predation on smolts immediately following their release from the barges. Radio-tagged yearling chinook survived from release below Bonneville Dam to the estuary whether they were transported or not. Level of descaling did not appear to affect the survival of radio-tagged chinook reaching the estuary or in their survival within the estuary.

Stress

Nearly all of the information concerning the impacts of the transportation process on the physiology and performance of migrating smolts has been derived from experiments with hatchery fish (Schreck et al.1997a).

In the early 1980s, researchers began evaluating facilities used for the collection, bypass, and transport of outmigrating chinook salmon. The response of juvenile salmon has been assessed by measuring various physiological, performance, and behavioral traits. Studies show that collection facilities and procedures increase stress among juvenile salmonids. Much of what has been learned from this work has been directly applied to management of the juvenile fish transportation program (i.e, addition of pre-anesthesia systems, open-channel flumes, shaded raceways, enlarged barge release exits, etc.).

1. Recovery From Stress

Elevated plasma cortisol levels associated with stress induced by handling and marking procedures have been found to decrease significantly (to pre-mark levels) during truck transportation (Matthews et al. 1987). The results of an 1993 study indicate that, though stress indicators in juvenile salmonids are initially elevated (plasma cortisol, white blood cell levels, composition of white blood cells, diminished avoidance behavior), they decrease as the fish are barged downriver (Schreck and Congleton 1993). Studies in 1994, however, showed that the ability of yearling chinook salmon sampled from a barge at Lower Granite Dam to survive a saltwater challenge was reduced on each of three successive test dates over the course of the juvenile migration (Schreck and Congleton 1994). More recent studies (early season trials) indicate that elevated blood plasma cortisol levels (a physiological indicator of stress) in barged chinook salmon and steelhead largely return to normal during the trip downriver. However, at the peak of the migration, plasma cortisol levels in yearling chinook salmon remain elevated throughout the collection and transportation process (Schreck et al. unpublished reports). Results from late season trials have been mixed.

2. Differences in Stress Response of Hatchery and Wild Chinook

Plasma cortisol concentrations taken from wild and hatchery chinook salmon in barges at Lower Granite Dam were consistently and significantly higher in the wild fish throughout the migration. The highest cortisol concentrations in both groups occurred during peak movement of juvenile chinook salmon into the collection facility (Schreck and Congleton 1994). These data suggest that recovery from collection and loading stressors is related to loading density. Mixing species together during collection and transportation may also be a factor.

3. Steelhead Response to Stress

Studies in 1994 and 1995 showed that collection and loading were also stressful to migrating juvenile steelhead. Steelhead smolt recovery during transportation appeared to vary widely over the course of the migration season—ranging from full recovery to pre-collection level, significantly declined but above pre-collection level, or to below pre-collection levels. It is of interest to note that in the 1994 studies, stress indices did not decline to pre-collection levels during barge transportation to below Bonneville Dam or even to Tongue Point (an additional 20 hours of potential recovery time) (Schreck et al., unpublished reports).

In 1997, a laboratory experiment was conducted to determine how well steelhead tolerate a stressful event: the water level was lowered for 15 minutes at various intervals after intentionally descaling 20 percent of the steelhead's body surface on the dorsal side. The fish were sampled 16 hours after the stress event. Both descaling and exposure to low water level resulted in significant increases in enzyme levels. However, no statistically significant interactions between descaling treatment and stress exposure were found, thus suggesting that the responses to the stressor were similar for descaled and control fish at all times after descaling (Congleton et al. 1997).

4. Mixed Species Effects on Juvenile Chinook

Laboratory studies intended to simulate transportation practices were conducted in 1995 and 1996. They indicate that the presence of rainbow trout (surrogate steelhead) affected the behavior and physiology of juvenile hatchery chinook (Willamette River stock). Behavioral data indicate that the rainbow trout were very aggressive, while the chinook were passive. In confinement, the schooling behavior of the chinook did not appear to be compatible with the territorial behavior of the rainbow trout. Physiological studies found that the chinook had higher levels of plasma cortisol after rainbow trout were loaded in than did chinook in control tanks (no loading) or in tanks loaded with additional chinook. A second experiment found that plasma cortisol levels in chinook that received inflow containing rainbow trout odor were initially similar to control group levels. However, plasma cortisol levels increased two hours after the odor was introduced (Kelsey 1997, Schreck et al. unpublished reports). These data support the need for improving fish size separation to reduce species interactions.

Size separation efficiency is poor for smaller-sized salmon (yearling chinook, sockeye, coho) collected at the new juvenile facility at McNary Dam. This is due, in part, to the fact that there has been no need for size separation because all spring migrants have been returned to the river at McNary since 1995. In 1994, the first year the new juvenile facility was in operation, only 27 percent of the sockeye salmon collected entered the small fish distribution route (a-side). The remaining sockeye (73 percent) were routed to raceways containing larger salmonids (primarily steelhead) for transport.

5. Concern for Mixed Species Effects on Sockeye at McNary

Some biologists are concerned about the impacts that the larger hatchery steelhead may have on the 80 to 90 mm long sockeye during transport from McNary Dam. We were unable to determine whether species-specific information on physiological indicators of stress exist for this location. However, some level of assurance may be based on available results of the 1995 transport vs. in-river study at Lower Granite Dam. Presently, juvenile fish can not be separated by size at Lower

Granite; therefore, small and large fish are transported together. In the 1995 study protocol, marked yearling chinook were returned to raceways containing steelhead before transport. The proportions of marked chinook from the 1995 study and unmarked steelhead transported in the same compartment were comparable to the species composition proportions in the other barge compartments. As previously discussed, preliminary study results of the 1995 study show that approximately twice as many adults returned from the transported groups compared to adult returns from groups allowed to migrate inriver. This data suggest that there was no long-term negative effect of mixed species transportation on the survival of yearling chinook.

Conclusion: Elevated levels of blood plasma cortisol (a physiological indicator of stress) in barged chinook salmon and steelhead are largely eliminated during transport. However, at the peak of the migration, plasma cortisol levels remain elevated throughout the collection and transportation process. Data suggest that recovery from collection and loading stressors is related to loading density. Mixing species together during collection and transportation may also be a factor.

Disease

The incidence of bacterial kidney disease (BKD) and the potential for transmitting it between wild and hatchery stocks of spring/summer chinook salmon collected for transport are being investigated by the U.S. Geological Survey, Biological Resource Division (formerly the National Biological Survey). The purpose of this research is to determine if BKD contributes to poor survival of spring/summer chinook salmon smolts (Elliott and Pascho 1993, 1994a,b). Laboratory cohabitation and waterborne experiments indicate that Renibacterium salmoninarum, the causative agent of BKD, can be transmitted to healthy chinook salmon smolts during a 48-hour exposure to infected chinook salmon. Results of the 1992 studies indicate a high concentration level of R. salmoninarum ($1x10^5$ cells per milliliter) may be required to infect more than 50 percent of the exposed fish within a 48-hour period (Elliott and Pascho 1994a).

Blood plasma samples from yearling chinook salmon in gatewells and barges at Lower Granite Dam, and from fish in the barges after transport, indicate that defenses against disease pathogens are significantly decreased after transportation (Schreck and Congleton 1994). In 1996, several assays were evaluated to determine their usefulness in evaluating the effects of stress on immune system function. Spring chinook juveniles (mid-Columbia River origin stocks) were held under crowded and uncrowded conditions (0.5 lb. fish/gal vs. 0.05 lb. fish/gal density) and sampled at 3-, 7-, 14-, and 21-day intervals. Interferon (a factor involved in resisting viral diseases) was moderately lower than measured in the controls in one trial and was unaffected in a second trial. Oxidative burst activity by blood neutrophils (a factor involved in eliminating pathogens) was significantly depressed in the groups of crowded fish at all time periods.

From 1988 through 1992, researchers evaluated the prevalence (frequency of occurrence) and severity (degree of infection) of R. salmoninarum among fish in marked groups of Columbia River and Snake River hatchery spring chinook salmon, both before their release and during their seaward migration. During the study, the prevalence of infection decreased in six of the eight hatchery groups. The researchers attributed this decrease to changes in hatchery practices that reduced vertical and horizontal transmission of the infection (Maule et al. 1996).

The 1988 through 1992 studies also found that spring chinook from Snake River hatcheries had a higher prevalence of R. salmoninarum infection when they were sampled at dams than they did in the hatchery; no similar differences were noted in comparisons of Columbia River fish. The authors thought these differences between Snake River and Columbia River fish might have resulted from differing in-river conditions and the distances from the hatcheries to the dams. They assumed that after being released from a hatchery, the most severely infected fish would die first. Therefore, increases in the prevalence and severity of infection suggest that the infection progressed during the migration. The fact that increased prevalence and severity was detected in the Snake River but not in the Columbia River, suggests that the changes were caused by the river environment and not by the fishes' decreased disease resistance during smoltification. The authors conclude that differences in water temperature and longer migration times caused hatchery fish migrating in the Snake River to experience higher prevalence and severity of R. salmoninarum than did those in the Columbia River (Maule et al. 1996).

Live box studies suggest that under certain conditions, uninfected salmonid smolts can become infected with R. salmoninarum (presumably shed from infected smolts) during in-river migration or transportation. These studies, however, did not define the levels of waterborne R. salmoninarum necessary for the normal smolts to become infected, nor did they define the probability of transmitting the disease from smolts with known infection levels to uninfected smolts (Elliott and Pascho 1995). Studies have shown that in most years, the highest mean antigen levels were measured in fish sampled after 75 percent of the total migration had passed a given dam. It is of particular significance to note that when the largest numbers of fish were being collected for bypass or transportation, mean antigen levels were relatively low (Elliott et al. 1997).

The juvenile fish transportation program has established criteria that govern the holding and loading operations. Specifically, collected fish may not be held longer than two days, and there is a maximum loading density of 0.5 pounds of fish per gallon of water. This density is normally only attained during peak spring migration periods when the fish are being transported by barge. Juvenile fish transport by barge from Lower Granite Dam normally takes about 35 to 40 hours, depending on weather conditions. According to Maule et al. (1987, 1989), decreasing the loading densities in raceways and ponds enhances specific immune responses of juvenile salmon. Therefore, the combination of segregating juveniles and reducing the holding and loading densities may decrease the potential to transmit of R. salmoninarum and enhance the fishes' ability to resist the pathogen.

Conclusion: Studies suggest that under certain conditions, uninfected salmonid smolts can become infected with bacterial kidney disease (presumably from infected smolts) during in-river migration or transportation. In most years, the highest mean antigen levels have been measured in fish sampled after 75 percent of the total migration had passed a given dam. Mean antigen levels were relatively low when the largest numbers of fish were being collected for bypass or transportation.

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Public Review Draft **March 18, 1998**

BASIS FOR NMFS DETERMINATIONS CONCERNING THE USE OF SPILL AS MITIGATION FOR OPERATION OF THE FEDERAL COLUMBIA RIVER POWER SYSTEM

March 1998

National Marine Fisheries Service
Northwest Region
7600 Sand Point Way NE
Seattle, Washington 98115

The Action Agencies have requested that the National Marine Fisheries Service (NMFS) reconsider the spill program required by the 1995 FCRPS Biological Opinion. It was their view that new information regarding the survival rate of transported fish warranted a reduction or elimination of spill at all projects where transport was possible. They also pointed out that new information such as spill effectiveness and changes in guidance efficiency should be considered when determining the appropriate spill levels for non-transport projects. The NMFS has decided to comprehensively review the 1995 spill program in response to this request.

Background

The spill program prescribed in the 1995 FCRPS Biological Opinion was developed to meet a fish passage efficiency (FPE) target of 80 percent at all dams where transport was not possible or when transport was not a priority. The 80 percent level was chosen as a surrogate for a dam survival estimates which were not available for all species at all dams and would be difficult to manage on an in-season basis. Based on generally accepted passage route survivals, NMFS estimated that the 80 percent FPE goal would provide dam passage survival of at least 95 percent at each dam. In practice, however, spill necessary to reach the 80 percent FPE level cannot be provided at some projects due to limits required to control total dissolved gas (TDG) levels within acceptable limits. The effects of spill and TDG on adult salmon was also a concern at many dams. Table 1 illustrates how FPE goals and therefore survival goals could not be met at several of the mainstem dams (except in some cases due to involuntary spill) under the 1995 Opinion spill program.

Table 1. Estimate of FPE's [1] under the 1995 FCRPS Opinion FGE and spill cap assumptions (assuming 100 kcfs total flow at Lower Granite Dam and 240 kcfs at McNary Dam).

Project	**FGE (%) [2]**	**80% FPE Spill (instantaneous kcfs)**	**120% TDG Spill Caps (kcfs)**	**Est. Actual FPE (%)**
LGR	50	87 (12 hr)	40	71
LGS	56	81 (12 hr)	35	67
LMN	55	82 (12 hr)	40	67
IHR	73	26 (24 hr)	25	80
MCN	70	118 (12 hr)	120	80
JDA	72	80 (12 hr)	50	77
TDA	43	156 (24 hr)	230	80
BON [3]	37 (P1) 44 (P2)	----	120	62

[1] FPE = (% of fish passing at night * ((night spill flow/total flow) * night spill efficiency rate))
+ (% of fish passing at night * (1-((night spill flow/total flow) * night spill efficiency rate))*FGE)
+ (% of fish passing during day * ((day spill flow/total flow) * day spill efficiency rate))
+ (% of fish passing during day * (1-((day spill flow/total flow) * day spill efficiency rate))*FGE)

[2] FGE estimates used in the 1995 Opinion were for mixed run yearling chinook salmon.

[3] 80% FPE spill is not achievable at Bonneville Dam because of daytime limitations to spill to limit adult fallback as well as TDG.

In the three years since the 1995 FCRPS Biological Opinion was signed, our knowledge of other factors affecting the spill program have changed. Fish guidance efficiency levels have increased at some dams following the installation of extended screens and FGE estimates have decreased at other dams because we have discovered weaknesses in our past methods of FGE measurement (Krasnow 1998 - DRAFT). For example, McNary Dam FGE has gone from a 1995 estimate of 70 percent to an estimate of 81 percent today due to installation of extended screens. John Day Dam FGE, on the other hand, dropped from a 1995 estimate of 72 to 57 percent today due to a better understanding of how older testing methods affected FGE estimates (Krasnow 1998 - DRAFT). Another change involved adjusting mixed run (hatchery and wild chinook) FGE estimates to reflect only hatchery chinook. This was done because some hatchery chinook are ESA listed and data from FGE estimates at some Snake River dams indicated that hatchery chinook do not guide as well as wild chinook (Krasnow 1998 - DRAFT). Juvenile chinook will continue to be used to estimate spill parameters since they do not guide as well as other listed fish and, therefore, represent the most sensitive listed fish. See table 2 for a complete listing of past and current chinook FGE estimates.

Also listed in table 2 are changes in spill caps since 1995. In most instances, the changes result from a better understanding of TDG levels after multiple seasons of monitoring in the river reaches below the spilling dams. In other cases, John Day and Ice Harbor dams for instance, the increase in spill resulted from gas abatement measures required by the 1995 FCRPS Biological Opinion and implemented by the Corps.

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Table 2. FGE's and spill caps estimated for the 1995 FCRPS Opinion and for the 1998 season

Project	1995 FGE [1] (%)	1998 FGE [2] (%)	1995-96 Spill Caps (kcfs@120% TDG) [3]	1998 Spill Caps (kcfs@120% TDG) [4]
LGR	50	73	40	45
LGS	56	76	35	60
LMN	55	47	50	40
IHR	73	60	25	75 [5]
MCN	70	81	120	150
JDA	72	57	50	180
TDA	43	39	230	230
BON	37 (P1)	32	120	120
	44 (P2)	37		

[1] FGE estimates used in the 1995 Biological Opinion, mixed run spring chinook.
[2] FGE estimates in Krasnow 1998 - DRAFT, hatchery spring chinook.
[3] Spill caps presented by the Corps, RCC to the technical management team in April 1996, based on 1995 spill and spring 1996 spill tests.
[4] Spill caps estimates from Tanovan, personal communication, February 3, 1996, except John Day estimate from Dach, personal communication, February 20, 1998.
[5] This spill cap is an early estimate based on preseason tests. The actual cap may change somewhat based on inseason observations.

Another significant change that has occurred is our understanding of how prescribed amounts of spill and total dissolved gas affect the prevalence and severity of gas bubble disease in migrating salmonids. When the spill program was first proposed in 1995, there was some uncertainty about how the prescribed TDG levels would affect juvenile and adult migrants. After three years of monitoring gas bubble disease we can now safely say that gas levels in the 115 to 120 percent range appear not to be a threat to migrating juvenile salmonids (Maule et al. 1997) . Gas levels experienced above the 120 percent level from uncontrolled spill in 1996 caused a higher prevalence of GBD signs, however, the severity of these signs remained low in all but the most extreme TDG levels (Maule et al. 1997). We have also seen very few signs (<1 percent) of GBD in adult migrating salmonids when gas levels are maintained at or below the 120 percent level (Backman et al. 1997). Therefore, our comfort level with 120 percent TDG spill levels is much higher than it was in 1995.

Based on the results of monitoring under the 1995 FCRPS Biological Opinion, NMFS reaffirmed our 1995 determination that a spill program that does not exceed 120 percent tailrace TDG (regardless of FPE) will increase survival of migrating juvenile salmonids. We also believe that moving past project FPE goals in the pursuit of the highest possible juvenile survival would not violate the intent of our dissolved gas waiver requests to the state water quality agencies. The intent of these waiver requests has always been to provide the best migrating conditions for juvenile salmonids while safeguarding the other aquatic biota. This intent was recognized by the Oregon Department of Environmental Quality and Washington Department of Ecology during a meeting on May 8, 1996.

Preliminary smolt to adult return information from PIT-tagged fish released at or above Lower Granite Dam in 1994 and 1995 shows a pattern of lower returns for fish detected at multiple dams relative to fish transported, detected at only one dam, or not detected at all as juveniles. This has led some agencies to suggest that spill survival is higher than bypass survival. Just what percentage of undetected fish actually went through spill is unknown since some of these fish could have passed undetected through turbines and bypass facilities with no or limited PIT-tag detection capability (e.g., Bonneville and The Dalles dams). However, it is possible that most of the undetected fish passed through the spillways since the study years included spill, particularly in 1995 when there were high amounts of uncontrolled spill 24 hours per day and limited spill effectiveness information suggests very high effectiveness for large amounts of 24 hour spill. At this point it is apparent that fish that likely went through the spillways (at least under the conditions tested) survived well in relation to other dam passage routes and that it is reasonable to assume that passing more fish through the spillways (within project specific limitations) would increase dam passage survival. The NMFS is currently evaluating these data and will provide more detail when this evaluation is completed.

These same PIT-tag based survival studies indicated that general survival of in-river migrants between Lower Granite and McNary dams decreased late in the spring migration. Some have pointed to this decrease and speculated that it was due to increased total dissolved gas levels in this river reach in May and early June. It is true that dissolved gas levels were high, in fact due to uncontrolled spill at Ice Harbor Dam each year, gas levels consistently reached 130 percent for long periods of time. It is, however, conjecture to say that these TDG levels caused the lower survival rates since there were other changing ambient conditions that could have affected survival (NMFS 1996 Annual Report to ODEQ). In any case, the TDG levels at Ice Harbor and other dams in this reach during the study years were much higher than the levels recommended in the NMFS spill program.

The spill program developed under the 1995 Opinion contained two basic types of spill scenarios at the FCRPS dams consisting of either 12 or 24 hour spill. These scenarios were prescribed for each dam depending on the type of juvenile migrant diel passage the dam was known to have. At dams with a relatively flat diel, i.e., dams were juvenile passage was about the same day and night such as Ice Harbor, The Dalles and Bonneville dams, 24 hour spill was prescribed. Twelve hour spill was prescribed at dams with a relatively high nighttime juvenile passage. At these dams, juveniles tended to pass in a crepuscular manner with the higher passage hours occurring in the evening and early morning hours. For example, using best diel passage data we have , a thirteen year period at John Day Dam, we calculate that 80 percent of the daily passage of spring chinook occurred between 1800 and 0600. Depending on the year, from 2 to 10 percent of this passage occurred between 1800 and 2000 and from 8 to 22 percent occurred between 0400 and 0600. It is apparent that shortening the spill period by cutting hours off either end would reduce the effectiveness of the spill scenario at this dam. The diel pattern is not as well known for other dams with 12 hour spill, however, we do know that passage at these dams is high at night and it is reasonable to assume that the crepuscular activity seen at John Day Dam holds true for these dams as well. For these reasons NMFS does not recommend shortening the 12 hour spill periods.

It is also worth noting that the uncontrolled spills in 1997 caused 24 hour spill at nearly every FCRPS project where prescribed spill would normally have been 12 hours. Another reason the 1995 Opinion prescribed 12 hour spill at several dams is out of concern for constant high TDG exposure to adults holding in the tailraces below these dams and the dams farther downstream. Data from adult monitoring at Bonneville Dam in 1997 indicated that up to 68 percent of adult sockeye salmon and 16 percent of adult steelhead examined during the highest TDG (>125 percent) periods exhibited signs of GBD while prevalence of signs in adult chinook was less than 1 percent (and similar to 1995 and 1996). At Lower Granite Dam (the only other consistent adult monitoring site) the prevalence of GBD signs in adult chinook was also low. These data appear to indicate that adults of some species are more susceptible to TDG than others. It also may indicate that, since the prevalence of GBD signs in 1997 was much higher in sockeye and steelhead than in 1995 and 1996, there may be a threshold TDG level and duration that these species respond to. Radio tracking studies and adult counts at ladders indicate that adults tend to hold in tailrace areas and ladder systems at night and move during the day. Vertical distribution of adults holding in the tailrace is largely unknown but existing data suggest that these fish are deep enough to receive at least some depth compensation for TDG supersaturation (depth compensation roughly equals 10 percent TDG for each meter of depth). Once adults move into the ladder system, however, they must move to shallower depths (within 8 feet from the surface at most ladders), thereby increasing their susceptibility to GBD. Cycling spill and TDG would help to reduce this susceptibility. The main point here is that our ability to detect and understand changes in adult GBD signs relative to changes in TDG must be better understood before NMFS can recommend 24 hour spill at the maximum gas cap at all dams.

Spill and Spill Related Recommendations

Because of the above mentioned changes NMFS has reconsidered the spill volumes and scenarios contained in the 1995 FCRPS Biological Opinion. To more closely approach the survival objectives in the 1995 Opinion, NMFS has determined that it is reasonable to increase spill volumes beyond the 80 percent FPE level at projects where this can be done without exceeding the current TDG cap (or other project specific limitations) during the 1998 and future fish passage seasons. Table 3 illustrates the differences in FPE and spill amounts (under a given flow scenario) between the recommended spill approach and an 80 percent FPE spill approach. As indicated, the estimated average FPE for the eight dams falls below 80 percent in both approaches, however, the gas cap limited spill approach comes somewhat closer.

Table 3. Estimate of FPE's and spill volumes obtainable in 1998 under a 1995 Biological Opinion type spill program (i.e., 80% FPE limit) vs those obtainable with a gas cap limited spill program (i.e., 120% TDG). Most spills are for 12 hours (1800 to 0600) unless otherwise specified. (Assume 100 kcfs total flow at LGR and 240 kcfs total flow at MCN.)

Project	1995 BiOp (80% FPE) Approach			Gas Cap Limited Spill Approach		
	Spill Volume (kcfs)	Instant Spill (%)	FPE [1]	Spill Volume (kcfs)	Instant Spill (%)	FPE [2]
LGR	20 (12 hrs)	20	80	45 (12 hrs)	45	85
LGS	25 "	25	80	60 "	60	86
LMN	40 "	40	61	40 "	40	61
IHR	55 (night)	55	80	75 (night)	75	84
	45 (day)	45		45 (day)	45	
MCN	0	0	81	150 (12 hrs)	63	89
JDA	148 (12 hrs)	65	80	180[4] (12 hrs)	60	79
TDA[3]	156 (24 hrs)	64	79	156 (24 hrs)	64	79
BON	120 (night)	50	59	120 (night)	50	59
	75 (day)	31		75 (day)	31	
Ave. FPE			75			78

[1] These FPE's are calculated with the same equation used in table 1, however, current FGE and TDG estimates are used. 80% FPE was used to cap spill.
[2] These FPE estimates are based on the same FGE and TDG data but the 120% gas cap and other project specific limitations were used to cap spill (limitations are described in the text below).
[3] Spill will be capped at 64% at this project, see project specific discussion in the text.
[4] The spill level at John Day Dam is capped at 180 kcfs for gas or 60% total flow due to tailrace conditions (see text below).

The specific spill volumes listed in Table 3 must be viewed as approximate "best case" since total dissolved gas levels measured at the monitoring sites below each project can vary for a given spill level depending on such factors as forebay dissolved gas level, spill patterns and water temperature changes. Also, there are many project specific limitations on spill levels for reasons other than dissolved gas. These include adult passage, navigation and research activities. These limitations are typically of short duration but they do reduce spill for fish passage to a limited degree. Specific recommendations and limitations for the system and each project are discussed below:

System wide

Gas bubble disease monitoring of juvenile and adult salmonids should continue at all the current sites as defined in the NMFS 1998 Gas Bubble Disease Monitoring Plan. It is the determination of the NMFS Dissolved Gas Team (D.T.) that the juvenile portion of the monitoring program has been reasonably well validated through annual research and monitoring conducted since 1994 (Mark Schneider, D.T. co-chair, pers. comm., March 2, 1998). However, two important research needs remain for the monitoring program including; (1) the need for a better understanding of the effects of extremely high near-field TDG levels on all salmonids and (2) verification of the adult salmon monitoring program.

Gas abatement studies should continue for all FCRPS dams including Chief Joseph and Grand Coulee Dam (including reducing high Boundary TDG levels). Even though there is no intentional fish passage in this reach, TDG generated by them contributes to system TDG and reduces our ability to provide fish protective spill at downstream dams.

Tailrace hydraulic conditions should be evaluated through general model studies to determine optimum spill patterns to minimize juvenile retention time in spill basins and tailraces and minimize adverse conditions for adult passage at all dams where this has not already been done. This work has been completed for existing conditions at Bonneville, The Dalles and John Day dams, partially completed for Ice Harbor Dam. Very little detailed information exists for McNary, Lower Monumental, Little Goose and Lower Granite dams, particularly for the potentially high percentage spills called for in this opinion. Scale model studies will allow a timely assessment of tailrace conditions in a stepwise manner through a full range of spill and total flow levels, and varied turbine unit operations. The final patterns should be verified to the extent possible through field observations after implementation.

Spill efficiency (flow per fish) and effectiveness (percent of total project passage) information are also needed at most dams under a variety of spill and flow conditions. Limited information from radio tagged juveniles passing during very high flow conditions in 1996 and 1997 at several dams indicate that different spill scenarios may be more effective at passing juvenile migrants. Information collected at John Day Dam in 1997 indicates that 24 hour spill may be much more effective than 12 hour spill in reducing residence time in the forebay by allowing fish to pass as they approach the dam. This study also indicated that for some species, daytime spill may be more effective than nighttime spill. If spill is limited to 12 hours for adult concerns, these studies can help identify which 12 hours are best. It is likely that the John Day Dam example could hold true for other FCRPS dams.

Another reason increase our knowledge of spill effectiveness is to allow more accurate estimates of smolt to adult returns (SAR) of PIT-tagged fish released in the hydrosystem. Currently, it is difficult to estimate how many tagged juveniles pass through the spillway and turbines because PIT-tags are only detected at bypass systems. SAR's can be determined for bypassed and non-bypassed fish but the non-bypassed component can not be accurately split into spill and turbine estimates. More accurate spill effectiveness estimates would allow greater accuracy in estimating this split.

Spillway survival estimates are needed at all dams under a variety of total flow and spill conditions. Currently, spill patterns and volume limitations are developed with general models of the dams at the Corps' Waterways Experiment Station based on general and somewhat subjective estimates of stilling basin retention time of juveniles, predation risk to juveniles and adult passage concerns. We are currently assessing adult passage through these tailraces but have done very little to estimate the effects these management options have on juvenile survival.

Lower Granite Dam

The 100 kcfs spill trigger specified in the 1995 FCRPS Biological Opinion has been reduced to 85 kcfs. Spill operations for fish passage must also consider critical research data needs relating to the proposed evaluation the prototype surface bypass/collector in Spring, 1998. Agreement on voluntary spill hours has not been reached but, in the absence of special operations for research, 12-hour nighttime spill is the most likely scenario. Powerhouse hydraulic capacity within 1 percent efficiency is about 123 kcfs, whereas, the Corps preferred operation this spring is 100 kcfs though the powerhouse and 6 kcfs over the spillway.

Dissolved gas limitations - Depending on ambient forebay gas levels, spill to the 120 percent TDG saturation will be limited to about 45 kcfs.

Powerhouse flow limitations - Powerhouse hydraulic capacity within 1 percent efficiency is about 123 kcfs. Total river flows above this volume will cause involuntary spill. BPA has specified that 11.5 kcfs is the minimum powerhouse flow. The Corps' Fish Passage Plan (FPP) specifies that units 1, 2, and 3, be given operating priority for fish passage during the daytime and the larger units (4, 5, and 6) at night.

Tailrace limitations - Limitation of spill may be necessary in order to limit adverse hydraulic conditions in the tailrace. Poor hydraulic conditions resulting in large tailrace eddies can reduce adult passage efficiency and increase predation on juveniles passing through the spillway and bypass system. Past adult radiotracking data (Turner et al. 1983) indicate that daytime spill should be limited to 25 kcfs to maintain good adult passage conditions. For the 12 hour nighttime spill period, this limitation would only apply between 0500 and 0600. Specific tailrace spill pattern modeling studies have not been conducted to identify other spill limitations at Lower Granite, however, it is known that as spill levels increase a large eddy forms below the powerhouse depending on spill level and turbine unit operations. Until modeling studies can be done, the need for spill limitations to minimize this eddy will be assessed inseason by the TMT.

Little Goose Dam

Continue 12-hour nighttime spill at this project. PIT-tagged fish will returned to the river after PIT-tag detection, whereas, other collected fish will be transported. Barge loading normally occurs in the late afternoon and can be hampered when two barges are in tow. A new secondary bypass system was installed for the 1997 season which releases bypassed smolts into positive downstream flow conditions.

Dissolved gas limitations - Depending on ambient forebay gas levels, spill to the 120 percent TDG saturation will be limited to about 60 kcfs.

Powerhouse flow limitations - Powerhouse hydraulic capacity with unit operation within 1 percent efficiency is approximately 123 kcfs. BPA has specified that 11.5 kcfs is the minimum powerhouse flow. The FPP specifies that units 1, 2, and 3, be given operating priority for fish passage during the daytime and the larger units (4, 5, and 6) at night.

Tailrace limitations - Limitation of spill may be necessary to limit adverse hydraulic conditions in the tailrace. Poor hydraulic conditions resulting in large tailrace eddies can reduce adult passage efficiency and increase predation on juveniles passing through the spillway and bypass system. Past adult radiotracking data (Turner et al. 1983) indicate that daytime spill should be limited to 25 kcfs to maintain good adult passage conditions. For the 12 hour nighttime spill period, this limitation would only apply between 0500 and 0600. Specific tailrace spill pattern modeling studies have not been conducted to identify other spill limitations at Little Goose, however, inseason observations indicate that an eddy forms below the powerhouse with as little as 35 percent spill. The need for spill limitations to minimize this eddy will be assessed inseason by the TMT.

Lower Monumental Dam

Continue 12-hour nighttime spill at this project. PIT-tagged fish will be returned to the river after PIT-tag detection, whereas, other collected fish will be transported.

Dissolved gas limitations - Depending on ambient forebay gas levels, spill to the 120 percent TDG saturation will be limited to about 40 kcfs.

Powerhouse flow limitations - Powerhouse hydraulic capacity with unit operation within 1 percent efficiency is approximately 123 kcfs. BPA has specified that 11.5 kcfs is the minimum powerhouse flow. The FPP specifies that units 1, 2, and 3, be given operating priority for fish passage.

Tailrace limitations - Adverse hydraulic conditions (eddy at JBS outfall) during high spill periods (60 to 70 kcfs) have been observed at this project but have not yet been calibrated.

Inseason observations indicate that spill levels of 50 percent or less may be necessary to minimize the eddy below the powerhouse. Due to the lack of specific data, the need for spill limitations to minimize this eddy will be assessed inseason by the TMT.

Navigation limitations - Barge loading for the juvenile transportation program normally occurs in the evening hours and has in the past been hampered by voluntary spill. A new mooring dolphin has been installed and is expected to allow spill to continue during barge loading in 1998 and future years however, spill may need to temporarily be reduced to accommodate the loading process.

Ice Harbor Dam

Hydroacoustic studies conducted by the Corps (BioSonics) have indicated a relatively flat diel passage of juvenile migrants through this spillway. This passage pattern supports continued 24-hour spill this project.

Dissolved gas limitations - Spill at Ice Harbor Dam will increase due to the additional spill deflectors installed in 1997. Spill to the 120 percent TDG saturation with 8 of 10 spillbays equipped with deflectors is anticipated to be approximately 75 kcfs

Powerhouse flow limitations - Powerhouse hydraulic capacity with unit operation within 1 percent efficiency is approx. 94 kcfs. BPA has specified minimum powerhouse flows of 7.5 to 9.5 kcfs. The FPP specifies that units 1,3, 4, and 2, be given operating priority for fish passage.

Tailrace limitations - A reduction in spill levels may be required as spill levels approach total river flow levels to maintain good hydraulic conditions in the tailrace. Poor hydraulic conditions resulting in large tailrace eddies can reduce adult passage efficiency and increase predation on juveniles passing through the spillway and bypass system. Preliminary tailrace spill pattern modeling studies have been conducted to optimize spill patterns, however, specific spill volume limitations (other than for barge traffic) were not determined. Past radio tracking studies on adult passage indicate that a daytime spill cap of approximately 45 kcfs is necessary to maintain good adult passage (Turner et al. 1984). This daytime cap should be in effect from 0500 to 1800. The addition of spill flow deflectors in late 1997 may affect this cap. The need for modification of these limitations will be assessed inseason by the TMT.

Navigation limitations - When river flows exceed 100 kcfs, spill flow causes problems for barge traffic exiting the navigation lock. The Corps has indicated they will reduce spill as long as necessary to pass navigation traffic. An alternative spill schedule for this purpose is included in the Corps' Fish Passage Plan.

McNary Dam

Continue 12-hour nighttime spill and the secondary bypass of juvenile salmonids back to the river.

Dissolved gas limitations - Depending on ambient forebay gas levels, the 120 percent TDG cap may range between 120 and 160 kcfs.

Powerhouse flow limitations - Powerhouse hydraulic capacity with unit operation within 1 percent efficiency is approximately 170 to 175 kcfs. This low capacity will cause involuntary spill to occur at normal spring flow levels. BPA has specified a minimum powerhouse flow of 50 kcfs. The FPP specifies that units 1,2, and 3 be given operating priority for fish passage.
Tailrace limitations - A reduction in spill levels may be required at high spill percentages to maintain good hydraulic conditions for juvenile and adult passage in the tailrace. However, observations in the tailrace during high spill flows have not indicated a problem. This may be due to the bathymetric and shoreline configuration of this tailrace which tends to force powerhouse flow in a northwesterly direction (towards the spillway side of the river) as it moves downstream. Nevertheless, since specific tailrace spill pattern modeling studies have not been conducted to identify spill limitations under a variety of flow and unit operation conditions, the need for limitations should be assessed inseason by the TMT.

John Day Dam

Spill at John Day Dam will increase in 1998 due to completion of spillway flow deflectors in late 1997. Twenty-four hour spill should be investigated in 1999. High spillway effectiveness and high daytime passage was noted during 24 hour spill in 1997 (Corps memo, February 3, 1998). Effectiveness was highest during the summer but daytime passage was much higher than expected in both spring and summer indicating a potential decrease in forebay residence time and subsequent predator exposure in this area.
Dissolved gas limitations - Nearfield TDG tests conducted in early 1998 indicate that spill volumes generating 120 percent TDG may be as high as 180 kcfs. Actual spill volumes will have to be determined in season since forebay gas level will likely affect this estimate.
Powerhouse flow limitations - BPA has specified a minimum powerhouse flow of 50 kcfs.
Tailrace limitations - Spill volume at this project will be limited by tailrace conditions under high spill percentages and medium to low total river volume. In the gas cap limited spill scenario illustrated in table 3 above, 144 kcfs of 240 kcfs total flow (60 percent) was spilled. Based on model studies at the Corps' Waterways Experiment Station under a variety of simulated flow levels, this percentage of spill is the maximum that does not cause the formation of a large eddy below the powerhouse, particularly in the vicinity of the juvenile outfall. These model studies also indicated that at least 25 percent spill was needed to create acceptable tailrace conditions below the spillway. Additional model studies scheduled prior to the start of the 1998 spill season will help refine these limits.

The Dalles Dam

No change is recommended to the current The Dalles Dam spill scenario (other than necessary for research) until the ongoing spill studies are completed. The research completed to date indicates that this spillway is not a benign passage route and that this spillway may be very efficient in passing fish. After one year of research, the survival study has indicated that, under very high spill levels (>250 kcfs), survival of the test fish (coho and subyearling chinook) was less than anticipated (86 to 93 percent) (Dawley et al. -- DRAFT). Survival of subyearling chinook was higher and these fish were passed through the system under lower spill levels indicating a possible connection between spill volume and survival. Also, percentages of spill greater than about 40 percent send increasing amounts of water and fish over shallow rocky shelves just downstream of the spillway. Fish swept into these areas are more likely to be fall victim to predation than fish the stay in the main channel. It is unknown if this predation reduces spill survival to something less than turbine survival. However increasing spill above the 40 percent level is likely moving in the direction of increased harm. More studies are needed before any management changes are warranted.

Dissolved gas limitation - Depending on ambient forebay dissolved gas levels, the 120 percent TDG cap can be as high as 230 kcfs at this project.

Powerhouse flow limitations - BPA has specified a minimum powerhouse flow of 50 kcfs.

Tailrace limitations - Because of our concern for juvenile survival through the spillway at high spill percentages and volumes, we are recommending limiting spill to the 1995 FCRPS Biological Opinion level of 64 percent (rather than spilling to the TDG gas cap). The ongoing studies on passage survival and spill efficiency and effectiveness must be completed. In addition and pending results of another year of survival studies, scoping should begin on methods to improve spillway survival at this dam (e.g., reconfigure the hydraulic characteristics of the stilling basin to reduce juvenile residence time).

Research limitations - Limited hydroacoustic data from 1996 studies indicate that 30 percent spill may be as effective at passing fish as the 1995 Opinion required 64 percent (BioSonics, Inc. 1997). Unfortunately, only 3 days of valid tests were completed at the 30 percent spill level. Additional tests scheduled for 1998 will help define this issue. Spill will be limited to 30 percent for approximately 50 percent of the 1998 fish passage season.

Bonneville Dam

No change is recommended to the Bonneville Dam spill scenario at this time. Spill, and therefore FPE, is limited by a relatively low TDG cap and by concerns for adult fallback during the daylight hours. These two issues should be the focus of continued research. Specifically, the Action Agencies should continue the ongoing project specific gas abatement program for Bonneville Dam with focus on evaluating endbay flow deflectors and eliminating deep holes in the near tailrace. This work must also consider the effects implementation of abatement measures may have on passage and safety of adult and juvenile salmonids. The

ongoing study to reduce fallback of adults through the spillway should be expedited.
Dissolved gas limitation - Depending on ambient forebay dissolved gas levels, the 120 percent TDG cap is in the 100 to 150 kcfs range and averages about 120 kcfs at this project.

Powerhouse flow limitations - BPA has specified a minimum powerhouse flow of 30 kcfs.
Tailrace limitations - Model studies conducted in the early 1990's defined the current spill pattern for Bonneville Dam. These same studies indicated a minimum spill level of 50 kcfs was necessary for adequate tailrace hydraulic conditions. There is no maximum cap for fish passage. Because of the unique configuration of Bonneville Dam, flow from the spillway does not directly effect tailrace patterns below either of the two powerhouses.
Adult fallback limitation - Adult fallback through the spillway is known to be correlated to spill flow (Monan and Liscom 1975). The current spill cap for daylight hours is 75 kcfs.

Public Review Draft **March 18, 1998**

Response to the Questions of the Implementation Team Regarding Juvenile Salmon Transportation in the 1998 Season

ISAB REPORT 98-2

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February 27, 1998
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EXECUTIVE SUMMARY

This report is the ISAB response to three questions raised by the National Marine Fisheries Services' Implementation Team in the letter of December 3, 1997 from Dr. Michael Schiewe, National Marine Fisheries Service, to Dr. Richard Williams, Chair of the ISAB concerning the possible consequences of juvenile transportation in 1998 on subsequent adult returns and straying of salmon and steelhead from the Snake River. During the course of preparing answers to the questions, the ISAB noted a mismatch between the questions and the available information. The method of transportation for which information is available is not the same as the current method of transport. The kinds of fish on which transport has been tested are not the same as those for which protection is most critical, thelisted species. Therefore, drawing analogies between different modes oftransportation and different species of fish introduces substantial uncertainty. Given the magnitude of uncertainty imposed by the nature andextent of available information, it continues to be prudent to exercisecaution in weighing the possible risks against the perceived benefits of juvenile transportation. Here are brief answers to the questions.

1. " ... are there real and significant differences (differences that areboth statistically significant and meaningful biologically) under the range of flow conditions for which data exists, in the survival to adult returns between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in-river?"

Statistically significant differences have not been documented on a stock by stock basis. The present mixed-stock truck and barge transportation system probably would improve survival for some affected populations, given the same in-river survival levels present during the NMFS studies. However, the effect of transportation on any particular population is unknown. Barging juvenile stream type chinook (spring/summer) and steelhead should improve survival for some populations of these two types of fish, but it is not known which populations would benefit. It is important for managers to understand how individual populations fare under transport, because the combined effects of collection and transportation may decrease survival for some populations, life history types and species. With respect to the Snake River, the effects of barging have been systematically studied with modern (post-1982) tagging methods only for stream type chinook and steelhead taken as a single group. Although some portion of all emigrants is trucked, the effects of trucking juveniles from the Snake River have not been systematically studied. The effects of transport accrue only to those animals entrained (collected) in the bypass systems. Ample evidence is available to demonstrate that the collection efficiency of each bypass system varies by species, life history type and population. Within species and populations, the collection efficiency of the bypass systems is a function of the physiological state of the fish, time of year, and other factors.

2. " ... are there real and significant differences (differences that are both statistically significant and meaningful biologically) under the range of flow conditions for which data exists, in the straying rate between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in-river?"

There are sometimes differences in the straying rate between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in the river. Documented instances of transportation-related straying appear to be related to lack of adequate imprinting, and most often occurred in the course of truck transportation. Differences had no apparent relation to the range of flow conditions prevalent for the experimental lots of fish for which these differences were measured, but reviews on this subject have been limited. Whether or not the observed differences in straying rate are biologically meaningful is unknown. Without knowledge of whether the differences are biologically meaningful, questions concerning statistical significance are meaningless.

3. " Based on your comprehensive review and analyses of whether differences in survival to adult returns and straying rate are real and significant, what is the likelihood that collection and transportation of salmon and steelhead at the Snake River projects and McNary Dam in 1998 will result in an increased adult return compared to allowing those same fish to migrate in-river?"

Considering all species, life history types and populations together, the effects of combined trucking and barging on adult return and straying rates are uncertain. For the stream type chinook (spring/summer) salmon and steelhead populations of some hatcheries and watersheds, it is likely that collection and barge transportation in 1998 would result in an increased adult return compared to allowing those same types of fish to migrate in-river, given that hydroelectric operations in 1998 are representative of the past. However, the increase in stream type chinook salmon and steelhead could be the result of selective enhancement only of some stocks, and we have no basis for knowing which stocks would benefit and which might be disadvantaged by this action. We emphasize that the benefit of any single action, such as smolt transportation, needs to be evaluated not only for its average benefit, but also in regard to the variation in benefits within and between populations.

RECOMMENDATIONS

1. We recommend a 1998 management approach that divides juvenile emigrants throughout the migration season between barging and natural emigration. In the long term,the result should be to apply mitigation measures evenly across all stocks. The 1998 management approach should work in concert with hydroelectric system operations that maximize survival of natural emigrants. The available information does not support taking the majority of emigrants of any stock into transportation. A spread the risk approach involving the use of barges, spill and other measures intended to enhance downstream passage survivals should be started each year as early as

possible and continued as late as possible to protect the entire spectrum of the salmon and steelhead emigration.

2. We recommend that trucks not be used in the transportation program. There is a paucity of data on the effects of Snake River trucking on salmon and steelhead so that necessary information to guide management actions is absent. Most historical information on truck transportation shows lesser survival benefits and more problems with homing than have been experienced with barge transportation.

3. We recommend that management actions intended to protect salmon and steelhead be population specific to the maximum extent possible. Management decisions should be based on the expected outcomes of clearly defined actions on the spawning populations from specific watersheds, as opposed to extension of T/C comparisons of outcomes of mixed stocks resulting from unspecified actions. For the protection and enhancement of life history and stock diversity that is critical for recovery, it is important that comparisons of survival of transported and natural emigrants be assessed based on returns to, and spawning success within, the spawning grounds of individual stocks.

INTRODUCTION

This report is the ISAB response to three questions raised by the National Marine Fisheries Services' Implementation Team in the letter of December 3, 1997 from Dr. Michael Schiewe, National Marine Fisheries Service, to Dr. Richard Williams, Chair of the ISAB. The questions asked were:

1. " ... are there real and significant differences (differences that are both statistically significant and meaningful biologically) under the range of flow conditions for which data exists, in the survival to adult returns between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in-river?"

2. " ... are there real and significant differences (differences that are both statistically significant and meaningful biologically) under the range of flow conditions for which data exists, in the straying rate between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in -river?"

3. " Based on your comprehensive review and analyses of whether differences in survival to adult returns and straying rate are real and significant, what is the likelihood that collection and transportation of salmon and steelhead at the Snake River projects and McNary Dam in 1998 will result in an increased adult return compared to allowing those same fish to migrate in-river?"

PROCEDURE FOLLOWED

In developing our response, we arranged a briefing at a December 17, 1997 meeting of the ISAB in Portland. We invited interested parties to participate in the briefing. Participants were representatives of the National Marine Fisheries Service, the U.S. Army Corps of Engineers, Idaho Department of Fish and Game, and the Columbia River Intertribal Fish Commission. We also received a written briefing from Oregon Department of Fish and Wildlife. In addition to these, we relied upon the references cited at the end of this report. We would have preferred to produce a formally documented, in-depth report, but available time did not allow such a response. Available time was constrained by the requirement to provide analysis useful for 1998 management decisions.

We applied the conceptual foundation developed by the Independent Scientific Group in Return to the River (ISG 1996) to the questions before attempting to answer them. From that perspective, it became apparent that the questions of December 3, as well as the original concept of transportation, assumes that a single answer exists with respect to the effects of transportation on salmon and steelhead without reference to differential effects on species or specific populations, or the conditions imposed by different modes of transportation. In Return to the River, the ISG described three elements of a conceptual foundation, the third of which applies to this situation, "Life history diversity, genetic diversity and metapopulation organization are ways salmon adapt to their complex and connected habitats" (ISG 1996). These essential factors (population complexity and diversity) enable salmonids to cope with environmental variation that is typical of freshwater and marine environments (ISG, 1996).

An overarching question is therefore raised as to whether the various types of transportation affect all salmonid species, life history types and populations equally (i.e., it is non-selective) or whether they affect different species, life history types and populations differently (i.e., it is selective). If the latter, the transportation program may benefit some stocks, while at the same time eroding overall levels of life history diversity, genetic diversity and metapopulation organization essential to sustainable production. We address this overarching question in our response.

ISAB RESPONSES TO THE QUESTIONS

1. " ... are there real and significant differences (differences that are both statistically significant and meaningful biologically) under the range of flow conditions for which data exists, in the survival to adult returns between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in-river?"

The data suggest differences in the rates of survival to adult returns between stream type (spring/summer) salmon and steelhead that are transported as juveniles versus those left to migrate in-river. These differences, transport minus in-river, are both positive and negative, but total annual differences are more likely to be positive than negative. The extent to which any difference may be biologically meaningful appears to depend on a number of physical and biological factors. The physical factors include watershed of origin (e.g. the distance of the rearing grounds from the point of transportation, and the related factor of time of the year of transport), and the biological factors include species, life history type, and population. Population specific factors such as rate of growth and state of maturity on entering the hydroelectric system may also determine the extent to which transport is biologically meaningful. As a consequence, transport is unlikely to be biologically meaningful to all of the salmon and steelhead populations in the Snake River basin, although it could be biologically meaningful to some stream type populations. Some of the observed differences for stream type salmon and steelhead (both positive and negative) are statistically significant based on our limited review of original data. However statistical significance is primarily a function of sample size and does not insure that the differences are biologically meaningful.

2. " ... are there real and significant differences (differences that are both statistically significant and meaningful biologically) under the range of flow conditions for which data exists, in the straying rate between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in-river?"

There are sometimes differences in the straying rate between salmon and steelhead that are transported as juveniles versus those left to migrate as juveniles in the river. Documented instances of transportation related straying appear to be due to lack of imprinting. The largest rates of straying occurred in the course of truck transportation. Differences in straying rates have no apparent relation to the range of flow conditions prevalent for the experimental lots of fish for which these differences were measured. Whether or not the observed differences in straying rate are biologically meaningful is unknown. Without knowledge of whether the differences are biologically meaningful, questions concerning statistical significance are meaningless.

3. " Based on your comprehensive review and analyses of whether differences in survival to adult returns and straying rate are real and significant, what is the likelihood that collection and transportation of salmon and steelhead at the Snake River projects and McNary Dam in 1998 will result in an increased adult return compared to allowing those same fish to migrate in-river?"

For each and every Snake River salmon and steelhead population it is not likely that collection, trucking and barging at the Snake River projects and McNary Dam in 1998 would result in an increased adult return compared to allowing those same fish to migrate in-river. For some stream type salmon and steelhead populations, it is likely that collection and barge transportation would result in an increased adult return compared to allowing those same fish to migrate in-river. For other salmon and steelhead populations, collection and transportation may result in a decreased adult return compared to allowing those same fish to migrate in-river.

<u>Concluding response</u>

It is impossible to reconcile a maximum transport approach to salmon recovery with protection of the remaining diversity of salmon and steelhead populations in the Snake River basin. Our answers and conclusion are further discussed in the following sections.

SUPPORTING INFORMATION

The degree to which the available information on juvenile transportation is applicable to advising management in 1998 is a matter of concern. The method of transportation, barging, for which information is available, is not the same as the current method of transport, combined trucking and barging. The kinds of animals on which barge transport has been tested since 1982, run-of-the-river stream type (spring/summer) chinook and steelhead, are not the same as those for which protection is most critical, the listed species of fall chinook, sockeye, wild spring/summer chinook and wild steelhead. Run-of-the river animals are most likely to be steelhead and stream type chinook that originated in hatcheries, as opposed to the listed species that are by definition wild animals that originated from natural spawning. The degree to which information that was collected in the Snake River prior to 1983, or that was collected outside the Snake River basin at any time, may apply to the 1998 juvenile transportation management situation is a matter of some uncertainty. Nonetheless, the ISAB believes the following summary and interpretations of scientific information provide a useful context for consideration of the three questions on transportation.

Description of Transportation

The original concept of transportation was to provide salmon and steelhead smolts with a route of passage through the hydroelectric system that avoided the mortality they would otherwise experience in the reservoirs and at the dams. Collection of juvenile salmon for transportation depends upon their diversion by way of the turbine intake bypass systems at the dams (Mighetto and Ebel 1994). Transportation began as a management measure in 1975 after a decade of research led to the conclusion that in most cases, seasonal average adult return rates of mixed stocks of predominantly stream type salmonids that were transported as juveniles, exceeded the return rates of similar fish that migrated in-river (Ebel 1980; Ebel et al. 1973; Mighetto and Ebel 1994). Concerns about homing and straying induced by transportation have not been adequately addressed by research programs, although some studies have been attempted as reviewed by Mundy et al. (1994). More information on this subject is provided below in the section on Impairment of Homing.

Modern transportation experiments model "transportation" as a single treatment effect represented by barging (Achord et al. 1992, Harmon et al. 1989, 1993, 1995-96; Marsh et al. 1996, 1997; Matthews et al. 1990, 1992). The data for barging juvenile stream type chinook and steelhead in the Snake River suggest differences in the rates of survival to adult to the point of collection for transportation between stream type (spring/summer) chinook salmon and steelhead that are transported by barge as juveniles versus those left to migrate in-river (Ward et al. 1997).

Some of the observed differences in rate of return between transported and non-transported salmon (both positive and negative) are statistically significant based on our limited review of original data, and the analysis provided by Ward et al. (1997). However statistical significance does not insure that the differences are biologically meaningful.

Estimates of the effects of transport on survival of salmonids made after the 1982 season in the Snake River (Achord et al. 1992; Harmon et al. 1989, 1993, 1995-96; Marsh et al. 1996, 1997; Matthews et al. 1990, 1992) are generally regarded by researchers as being more reliable than those made before then (Matthews 1992). The improvement in reliability was due to advances in fish handling technology and time trends in physical conditions affecting survival in the hydroelectric system of the Snake River. Another limitation in interpretation of transport experiments is that time trends in stock composition of the experimental subjects are a factor in determining transport to control return rates (Matthews 1992). Large increases in the proportion of hatchery spring/summer chinook in transportation have been suggested as an explanation for unexpectedly low rates of adult return in transported subjects (Matthews 1992). For the purposes of management decisions, the results of the modern transportation experiments (Achord et al. 1992; Harmon et al. 1989, 1993, 1995-96; Marsh et al. 1996, 1997; Matthews et al. 1990, 1992) would be the most informative.

In contrast to the modern transport experiments, the actual method of transportation is not uniformly applied across species within a year, or within a species across years. Both barges and trucks are used in varying combinations to transport juvenile salmon and steelhead from the Snake River. Mixtures of many different populations, consisting of members of listed species, non-listed ESU species, and non-listed/non-ESU salmonid species, are moved down the river by various combinations of truck and barge trips during only a portion of each migration season. The transportation system is therefore a mixed-stock combined barge and truck operation applied to the numerical majority of the emigrants. Dring the five years ending in 1996, 92 percent (annual range 32 - 99%) of juvenile fall chinook transported from Lower Granite Dam were moved by truck. At the same location, during the same years, 24 percent (annual range 8 - 66%) of the wild sockeye/kokanee and 2.5 percent of the wild steelhead (annual range 1 - 4%) were moved by truck. During 1993 - 1996, nine percent (annual range 3 - 12%) of the wild spring/summer chinook were moved by truck from Lower Granite Dam.

Within the Snake River, information about the effects of truck and barge transport on other salmon life history types, on the populations of individual drainages, and on other anadromous species is lacking (Mundy et al. 1994; Harmon et al. 1995, 1996; Marsh et al. 1996, 1997; Ward et al. 1997). In particular, estimates of the effects of variable combinations of truck and barge transport from the Snake River for the four Snake River ESU's have not been made. The kinds of fish on which transport has been tested within the Snake River (Mundy et al. 1994; Harmon et al. 1995, 1996; Marsh et al. 1996, 1997; Ward et al. 1997) are not the same as those for which protection is most critical, the listed species. In the case of stream type chinook (spring and summer chinook) and steelhead, the effects on survival of barge transport from the Snake River have been compared to those emigrating within the federal hydroelectric system. Even so, stream type chinook and steelhead are much broader taxonomic groupings than the two listed species which they contain (Snake River wild spring/summer chinook and Snake River wild steelhead). Steelhead is a different species from sockeye, and fall, or ocean type, chinook. Stream type chinook is a life history type that is different from fall, or ocean type, chinook and it is a different species altogether from sockeye salmon.

Different species, life history types and populations of salmon and steelhead are expected to respond differently to any consistently applied means of juvenile transportation. Any single species, life history type, or population is expected to respond differently to variably applied types of juvenile transport. In the case of Snake River salmon, it is not advisable to use estimates derived from barging for one species to infer the consequences of combined trucking and barging for other species. As a group, the listed species are quite biologically diverse, and the type of transportation program applied each year differs among listed species, and within each listed species.

In spite of barge and truck transportation as a continuing management measure since 1980, threatened Snake River listed species of spring/summer and fall chinook, steelhead, and the endangered listed species of sockeye have continued to decline. The Proposed Recovery Plan for Snake River Salmon calls for improvements in both transportation and in-river passage (NMFS/NOAA 1995, p. V-2-13). Transportation is also recommended in the Northwest Power Planning Council's Fish and Wildlife Program (NPPC 1994) and in the report of the National Research Council's Committee on Protection and Management of Pacific Northwest Anadromous Salmonids (NRC 1996). Both the NPPC and the NRC attach caveats regarding uncertainty due to poorly understood factors, such as the possible effects of transportation on the homing ability of returning adults. At the same time, both the Independent Scientific Group appointed by the Northwest Power Planning Council and the NRC Committee concluded that transportation taken alone is not sufficient to overcome the current negative effects of habitat loss, hydropower operations and other sources of mortality for juvenile salmon (ISG 1996; NRC 1996).

Collection of salmon and steelhead smolts for transportation

Before they can be transported, salmon and steelhead smolts must be collected from the river. Interception takes place at the so-called "collector dams", as designated in the NMFS Proposed Recovery Plan (1995) for Snake River Salmon (Lower Granite, Little Goose and Lower Monumental). In addition, the barges and trucks that are loaded at the three Snake River collector dams may stop in the Columbia River at McNary Dam to take on individuals from the anadromous salmonid species that are collected there.

Ability to intercept anadromous salmonids depends upon the fish guidance efficiency (FGE) of the turbine intake screens in place at those projects (Whitney et al. 1997). FGE is different for each project, species, time of day (especially day versus night), design and configuration of the screen, degree of smoltification of the fish, and progress of the season. A further complication is that the bulk of stream type (yearling) chinook and steelhead are early emigrants, with sockeye being somewhat later, while ocean type (subyearling) chinook, though present through the season, predominate among the later emigrants (Fish Passage Center Annual Reports).

Thus, collection and transportation protocols are highly differential in application to species, life history type and population due to differences among populations in factors such as timing of downstream migration and arrival at collection sites, fish guidance efficiency, and whether the fish are transported by barge or truck. Intolerance to any of these modes of treatment could contribute progressively to loss of life history and population diversity. Moreover, when salmon populations are organized into metapopulations (NRC 1996, ISG 1996), transportation protocols that selectively favor certain populations over others could continue to erode, rather than restore, metapopulation integrity in river basins.

The modern assessments of Snake River transport of spring/summer chinook, as provided by current research programs (Achord et al. 1992; Harmon et al. 1989, 1993, 1995-96; Marsh et al. 1996, 1997; Matthews et al. 1990, 1992), apply only to mixed-stock barging, not trucking. Further we note that a single point estimate of the mixed-stock barging transport benefit ratio is highly unlikely to apply to the present combination of truck and barge transportation, let alone to capture the risk to salmon recovery posed by variability among spawning populations in the transport benefit ratio. Members of the spring/summer chinook ESU are not distinguished from other spring/summer chinook in the data gathering programs of the federal government on transportation (1996 Annual Report on Transportation, US Army Corps of Engineers). Although some hatchery spring/summer chinook are also members of the spring/summer chinook ESU, federal data gathering programs segregate the emigrants into "hatchery" and "wild" categories. There are no data and analyses that establish the applicability of barge transport benefit ratios (based on mixtures of hatchery and wild spring/summer chinook) to transport by both truck and barge of the listed spring/summer chinook species. We could find no analysis of the applicability of mixed stock barge transport benefit ratios to the listed spring/summer chinook salmon species. Application of a single estimate of an attribute to all populations of spring/summer chinook in the Snake River basin is not consistent with the federal recovery efforts and the ISG's conceptual foundation developed in Return to the River, nor is it advisable.

The fact that time of arrival of salmon at the dams has a clear effect on how and whether the emigrants are transported (see 1996 Annual Report of Transportation) illustrates the variable application of transport methods across populations and species. A variable proportion of each of the 38 spring chinook populations identified in the Proposed Recovery Plan (NMFS/NOAA 1995) will be subject to truck transportation each year. Trucking is invoked in response to declining numbers of downstream migrating smolts at different times each year as a means of saving on the cost of barging. Note that trucking of juveniles is based on an economic criterion, rather than a biological one, without a clear understanding of its biological outcomes. Consequently, spring chinook with relatively late and protracted timing of emigration, such as Imnaha spring chinook (Blenden et al. 1997), are more likely to be transported in trucks than are spring chinook with relatively relatively average emigration timing. Listed species emigrating later in the year, such as juvenile fall chinook, are highly likely to be trucked. Listed species with timings intermediate to spring and fall chinook, such as sockeye, are sometimes trucked or not (see 1996 Annual Report of Transportation). Emigrants that arrive after the close (end of October), or before the opening (beginning of April) of the present transportation season are not transported by any means at all. The extent to which some portions of some spring chinook populations may be moving down the river near the end of, and after the close of the transport season is not well known, however some juveniles are moving down the main Snake River at all times sampling is in place to detect them (1996 Annual Report of Transportation, USACE). For example, Kucera (presentation to Lower Snake River Compensation Program, Boise, Idaho, February 1998) reported that up to a third of the juvenile spring chinook tagged annually in the Imnaha River basin emigrated after September. An implication of these facts is that, in order to protect genetic diversity among the emigrants, management schedules should be based on timing of migratory behavior as verified by actual levels of abundance each season.

Impairment of upstream migration of transported salmon

Homing. Questions about possible effects of transportation on homing ability of salmon were addressed by NMFS/NOAA investigators in the early phases of their studies. They concluded that there was no evidence that relative return rates of transported and control groups are lower at locations beyond the capture site (Ebel et al. 1973; Slatick et al. 1975; Ebel et al. 1980). Mundy et al. (1994) observed that the early studies were not specifically designed to detect effects on homing, and that low recovery rates of test fish severely limited statistical power, independent of study designs.

Imprinting. Imprinting by juvenile salmon is a factor that needs to be considered in their transportation. There is an implicit assumption in the use of transportation that salmon will return to the desired point of origin (spawning grounds) rather than the point of release. At the same time, it has been demonstrated that salmon can be transferred to new locations (Fulton and Pearson 1981; Donaldson and Allen 1958; Vreeland et al.. 1975; Slaney et al. 1993; Wagner 1969; Cramer 1981). In fact, off-station release (transport by truck for release away from the hatchery) to enhance local fisheries, particularly of steelhead, has become a common practice throughout the Pacific Northwest (Johnson et al. 1990). In the mid-Columbia region, off-station releases of steelhead into the tributaries are the common practice of the Washington Department of Fish and Wildlife.

Transportation Effects on Homing. As noted above, the NMFS studies of salmon and steelhead transported by barge have revealed no apparent effect on homing or straying of returning adults, though conclusions relevant to transportation operations are limited by study designs (Mundy et al. 1994). On the other hand, where analyses are available on trucked fish, returning adults have been observed to exhibit some impairment in their ability to find their way. Immigrating sockeye and chinook adults that were transported as juveniles may use a passage route that differs from that of control fish (Chapman et al. 1997). Transported sockeye and chinook have shown higher rates of fallback as immigrating adults than did control fish (Chapman et al. 1997). Adult chinook and steelhead exhibited delayed or interrupted migration in the lower river (Bjornn and Ringe 1984; Hisata 1980). Hisata (1980) reported studies that included transport of steelhead by truck to below Priest Rapids Dam and to below Bonneville Dam and a group that was transferred from trucks to barges at Richland, WA for transport below Bonneville Dam. The group that was transferred from truck to barge at Richland exhibited more homing impairment than either of the other transported groups. In an attempt to improve homing ability, the fish in Bjorrn and Ringe's study (1984) and Hisata's (1980) study were acclimated in order that they would become imprinted to local waters prior to their transport, but to no avail.

Transportation Effects on Straying. Pascual and Quinn (1994) observed that chinook displaced from their hatchery of origin and released at other locations showed patterns of straying on return that were most similar to fish that originated from the new locations, rather than resembling patterns of fish released from their hatchery of origin. In a 1995 paper, after recognizing there is a genetic effect on homing, they hypothesized that, "...the fish must actually migrate at the time when they are exposed to the odors (upon which they will imprint) or they do not fully imprint on them." (Pascual, Quinn and Fuss 1995, p. 316).

Straying Rates. In Hisata's (1980) study, there were a total of 36 adult steelhead recaptured at Lower Granite Dam. Strays amounted to 15% of the total recoveries of transported fish and 2% of the combined control groups. Chapman et al. (1997) reported strays to tributaries outside of the mid-Columbia consisting of 7 transported sockeye and 3 controls out of over 3,000 comparable total adults recovered (0.3% total), and 11 transported chinook and 1 control out of perhaps 423 comparable fish (2.8% total). They felt that these numbers were not outside of what might be expected for any group of salmon. Bugert et al. (1997) reported that transported yearling fall chinook in their (Snake River) study strayed at a rate of 5.2% compared to 0.3% for control fish released in the river. Thus, the preponderance of evidence we examined showed that transportation by truck increased the rate of straying.

Recent observations (e.g., Chilcote 1998) of increasing numbers of stray Snake Basin steelhead into Columbia River tributaries, such as the Deschutes and John Day rivers, are cause for serious concern with respect to the genetic integrity of native steelhead stocks. It has not been determined what is responsible for this observed increase in steelhead straying. Given the literature record, described above, and given the present lack of specific information on the effects of the Snake River transportation program on homing and straying, transportation continues to be a factor of concern. Clearly additional monitoring and evaluation are needed on this problem.

To summarize the information on homing as it might be affected by transportation, we note that:
1. Salmon allowed to migrate naturally for a distance in the river before being collected for

transportation did not exhibit significant difficulties in homing to the point of collection, although their route of passage differed from control groups (Chapman et al. 1997).

2. There is no clear evidence of impairment of ability of transported fish to return to spawning grounds or hatcheries located above the point of collection, except that straying is increased for truck transported fish (various sources cited earlier).

3. "Acclimation" intended to imprint the fish as a substitute for migration in the river is not sufficient to provide necessary imprinting cues for transported fish (Hisata 1980, Bjornn and Ringe 1984).

4. The point of release of transported fish is important as it affects their passage route (Chapman et al. 1997).

5. There is a significant difference in return rates and impairment of homing between trucked and barged fish, with barged fish performing well and trucked fish performing poorly.

Alternatives to transportation

Juvenile salmon migrating downstream can pass through the turbines, through the intake bypass systems, or through spill (Whitney et al. 1997). Small numbers of juvenile salmon may pass through the navigation channels or fish ladders. Bypass systems are being altered to improve their effectiveness in increasing survival of some types and species of emigrants. Because FGE's have not been high enough to meet the NMFS or Council goals of 80% fish passage efficiency, FPE, (FPE = proportion not entering turbines) at all dams, spill has been provided during specified periods in amounts aimed at achieving the 80% passage goal. At times of low flow, this has necessitated shutting down some turbines. Surface bypass systems are presently being evaluated at several projects. Based on experience at Wells Dam, this approach offers a potential for achieving the 80% passage goal without the use of spill as an adjunct. Full testing and development of this alternative for the hydroelectric system is expected to extend over a number of years, and its ultimate effectiveness and its implementation schedule will be different for each dam.

A further factor in evaluating transportation is the fact that as fish passage facilities are installed and improved at the dams, mortality experienced by juvenile salmon migrating downstream is being reduced (Iwamoto et al. 1994; Muir et al. 1995, 1996; Whitney et al. 1997). Spill at the dams is an obvious alternative to transportation that has been demonstrated to improve survival for fish passing in the river that has been called for by both NMFS and the Council. For example, Wells, Dam has a fully functioning fish passage facility that successfully uses spill to divert 89% of the juvenile emigrants away from the turbine intakes. However, the Wells Dam is the only hydrocombine design among mainstem Columbia and Snake river dams. The hydrocombine design makes spill particularly attractive from both biological and economical perspectives. Rocky Reach, Rock Island, Wanapum and Priest Rapids dams pass a portion of the approaching fish through spill according to criteria established through proceedings of the Federal Energy Regulatory Commission. All of the Corps of Engineers projects on the Snake River as well as McNary and Bonneville dams on the lower mainstem are equipped with passage facilities. Passage may be able to replace transportation as a juvenile passage survival improvement measure. For example, Bugert et al. (1997) found no differences in rate of survival among control and transported groups of hatchery fall chinook released above and below respectively, two dams on the Snake River (Lower Monumental and Ice Harbor dams), during the period 1985 to 1990. Both of those projects were equipped with turbine intake bypass systems. Ward et al. (1997) reviewed 11 studies of transportation of chinook conducted over the period 1968 to 1989. Because conditions for in-river passage improved over that time period, they found it necessary to adjust data from 1979 to account for a range of estimates of reservoir and dam mortality by 14%, 16%, and 18%, while the data for 1986 and 1989 were adjusted by smaller numbers, 5%, 10% and 15%. We note that those numbers would be reduced still further under conditions at present, due to improvements in bypass facilities, provision of spill and other factors (Whitney et al. 1997). Improvements in bypass diminish the utility of transport for salmon recovery.

It should be noted, however, that application of spill and bypass has some of the same uncertainties as transportation. Information is needed on the characteristics of fish that are included in spill. Information is lacking on the mix of life history types or species composition of the fish included in spill and bypass. Similarly, evaluation of the efficacy of surface bypass needs to address the range of species and populations that may be expected to use it.

In summary, spill and bypass at the dams are alternatives to transportation that have been demonstrated to improve survival for fish passing in the river. Both have been called for by NMFS and the Council. The amount of spill appropriate to a given percentage of fish collection for transportation can be estimated, thereby minimizing the unnecessary collection of fish.

DISCUSSION

The ISAB noted with concern a mismatch between the focus of several ESA-driven recovery plans and programs with that of the transportation program. Outside the mainstem, federal recovery efforts are focused on protection of species, life history types and populations. Within the mainstem, federal recovery efforts depend heavily on a mitigation measure, truck and barge transportation, applied to the aggregate of all emigrants without knowledge of the impacts on individual species, life history types and populations.

The NMFS Proposed recovery plan (NMFS/NOAA 1995) identified 37 extant populations of spring/summer chinook, as well as one unlisted extant population within the Snake River basin (Table IV-1). It is clear from this that NMFS recognizes the importance of preserving the genetic diversity reflected in the adaptive differences between local populations within the ESU. Because the loss of genetic diversity can be irreversible, such losses could reduce the sustainability of recovery. Similarly, the recently published biological assessment for Upper Columbia and Snake

River steelhead (USACE 1998) makes clear the interdependence of multiple species on the effect of individual recovery measures. Recent reviews of the salmon recovery problem (ISG 1996; NRC 1996) have also placed considerable emphasis on population and life history diversity and expressed concerns over management actions, such as the transportation program, that may selectively benefit some stocks (particularly upriver hatchery origin stocks), while eroding overall species, population and life history diversity.

Current ecological science advises managers of exploited animal populations to protect the genetic and physical diversity of both the target populations and the ecosystem within which they exist (FAO 1995; Mangel et al. 1996). Existing transport studies (Achord et al. 1992; Harmon et al. 1989, 1993, 1995-96; Marsh et al. 1996, 1997; Matthews et al. 1990, 1992) were not intended to establish the impacts of transport on genetic diversity of listed species, nor on attributes of other species. In the long-term, protection of listed species will require protection of ecosystem functions, including allied aquatic species (Mangel et al. 1996).

In contrast, the transportation program focuses on the aggregate of all emigrants without knowledge of the impacts on individual species, life history types and populations. Evaluation and estimates of transportation effects are based on these aggregates, not on individual population estimates, therefore, extension of these T/C comparisons (based on groups of mixed stocks) to individual populations, particularly critically depressed ESA listed stocks, is fraught with uncertainty (see Mundy et al. 1994). The estimates for the effects of barge transportation on juvenile fall chinook from McNary Dam are presently being re-evaluated and will not be complete until the end of the 1998 season of adult returns (Marsh et al. 1997). But since the McNary fall chinook estimates are for barging, the revised estimates have serious limitations with respect to the Snake River, since the majority of juvenile Snake River fall chinook is transported by truck (1996 Annual Report of Juvenile Fish Transport, US Army Corps of Engineers). In the absence of other information for this type of salmon, it may be reasonable for managers to adopt the conclusion of Ward et al. (1998) "that large-scale transportation by truck was unlikely to benefit juvenile chinook salmon." (Ward et al. 1997, p. 652). In conclusion, we advise against excessive reliance on superficial interpretation of present data on tagged fish to draw inferences about the benefits of transportation. We found some of the assertions advanced at the December briefing to be open to question on several basic grounds. Examination of the methodological issues should be an important focus for future evaluations.

CONCLUSIONS

Conclusion: Spreading the risk of negative outcomes among alternative routes of hydroelectric passage is advisable to prevent a recovery action that is designed to improve survival of one listed species from becoming a factor in the decline of another species.

Conclusion: Spreading the risk of negative outcomes among alternative routes of hydroelectric passage is advisable in the face of uncertainties associated with potential negative effects of transportation on genetic and life history diversity.

Conclusion: Hydroelectric system operations need to be conducted to maximize survival for emigrants remaining within the Federal Columbia River Power System, regardless of the transportation protocol. Under all transportation protocols some natural emigrants will remain, because no bypass system can collect all individuals for transportation.

Conclusion: Spill at the dams is an alternative to transportation that has been demonstrated to improve survival for fish passing in the river. The amount of spill appropriate to a given percentage of fish collection for transportation can be estimated, thereby minimizing unnecessary collection of emigrants.

Conclusion: The application of mixed-stock barge and truck transportation to recovery of the listed salmon species in the Snake River during the 1998 salmon emigration season needs to be approached with caution.

Conclusion: Information specific to the listed species is particularly important when applying a type of recovery method such as the present collection and transportation system, because the present system of collection and transportation does not apply equally to all members of the ESU's, and other salmonid life history types.

Conclusion: The estimates of the survivals to adult of barge transported stream type (yearling) chinook and steelhead juveniles are not the same as those achieved by the present mixed-stock truck and barge transportation system for the four listed salmon species and their constituent populations.

Conclusion: Estimates of the effects of variable combinations of truck and barge transport from the Snake River are not available for any type of fish. Estimates of the effects of transportation applicable to individual species for barging alone, and for trucking alone, do not make possible statistical inferences on the effects of a transportation system that annually trucks and barges a variable percentage of multiple listed species each year.

Conclusion: Trucks should not be used in the transportation program due to lack of information needed to advise management, due to the absence of current research programs to collect such information, and because historical indications on truck transport are negative.

Conclusion: Barge transport alone may provide enhanced survival for some populations of the listed spring/summer chinook and steelhead species, but the effects of trucking on these populations is unknown.

Conclusion: As alternatives to transportation are getting closer to achieving hydroelectric project passage goals, emphasis should be placed on these approaches in preference to transportation insofar as they can avoid the difficulties experienced by some transported fish.

Conclusion: Application of the ISG's conceptual foundation to available information on transportation causes us to question whether any system of juvenile transport can be made compatible with the life history requirements of all migratory fish species and life history types (i.e. sockeye and anadromous kokanee) native to the Snake River basin.

Conclusion: Comparisons of transported and river-run fish should be evaluated by returns to the spawning grounds of individual stocks where the effects of transport on survival and spawning success may be measured for the full diversity of populations under management.

Conclusion: If the critically important, long-standing questions concerning the effect of transportation on listed species identified in this report cannot be answered, the application of juvenile transportation as a recovery tool for listed species will continue to include significant uncertainties.

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